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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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M 317

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Town Hall, Local Education Authority.
13th August, 1918. M 443

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A NEW THEORY OF THE STEAM TURBINE.

By HAROLD MEDWAY MARTIN, Wh.Sc., A.C.G.I.

(*Continued from page* 55.)

THE thermo-dynamic heads tabulated in Table V, page 107 *ante*, were calculated on the hypothesis that the wet steam was in thermal equilibrium throughout the whole of its expansion. It has long been known that this assumption is erroneous, but opinions have differed as the importance of the consequent loss from undercooling. The opinion most generally held has been that once the supersaturated steam began to condense, thermal equilibrium was practically instantaneously restored, and was maintained during any subsequent expansion. It will be shown in what follows that on this theory no rational basis can be found for the observed values of the superheat corrections.

The fact that nozzles fed with wet steam discharge a greater weight than can be accounted for on the ordinary theory has been traced to supersaturation of the steam as it passes the nozzle throat.

Arrived at first on theoretical grounds,* this conclusion has been confirmed experimentally by Professor Stodola, who, by strongly illuminating a high-velocity jet of steam flowing from a convergent nozzle, showed that there was not any visible sign of condensation until the steam had cleared the nozzle by a considerable amount. One of Dr. Stodola's photographs is reproduced in Fig. 5.

It should be noted that the presence of spray does not necessarily prove the absence of undercooling. In Dr. Stodola's tests, when ordinary boiler steam was led direct to the nozzle, a cloud of spray was visible close up to the nozzle discharge. To get the effect shown in Fig. 5 it was necessary to pass the steam through a separator before leading it to the nozzle. It is, however, known by experiment that a nozzle will pass a greater weight of ordinary boiler steam than would be possible were undercooling absent. The drops of water present can not in fact cool quickly enough to serve as condensation nuclei. Professor Callendar (Minutes of the Proceedings of the Institute of Civil Engineers, vol. cxxxi, page 172) has, indeed, obtained evidence of undercooling in the cylinder of an ordinary reciprocating engine, where the rate of expansion is very much slower than it is in a turbine.

This might, in fact, have been anticipated from the experiments of Aitken, in which, when dust-free but saturated air was expanded in what was mechanically analogous to a steam engine cylinder, no mist was produced, whilst when dust was present a cloud formed in the midst of the mass. Hence, if supersaturation of the steam is to be avoided, an area very much larger than is afforded by the walls of an engine cylinder must be available, and must, moreover, be well distributed throughout the whole mass of the gas. That supersaturation was likely to occur was pointed out by Maxwell as far back as 1880, yet this observation† was universally ignored, and indicator diagrams analysed on the hypothesis that the steam was in thermal equilibrium. It is not surprising that great difficulty has been found in co-ordinating results thus obtained.

The theory underlying Aitken's experiments is due to Lord Kelvin. The energy required to evaporate a drop of water is, of course, proportional to its weight, which varies as the cube of the diameter. As is well known, every free water surface is in a state of tension, and thus a certain amount of potential energy is stored in the surface film of a drop. This is proportional to the area of the surface, or, in other words, to the square of the drop diameter. Hence, as the diameter of the drop diminishes the potential energy stored in the surface film decreases less rapidly than the energy required to evaporate the contents of the drop, and at some point or other the two become equal. Once this point is reached the drop automatically evaporates. Conversely, a drop must start of a certain size and cannot commence on an infinitesimal scale. In no case can a drop of pure water be in equilibrium with steam of the same temperature. If both the drop and the surrounding vapour are at the same temperature the drop must evaporate. The fact that droplets are observed to persist even in the midst of superheated steam is due to the fact that such drops are not drops of pure water, but, having arisen from priming, contain dissolved salts, and have thus a lower vapour pressure than pure water.

The conditions in which a drop of pure water is in equilibrium with its surroundings can be established as follows:—Conceive a capillary tube made of a substance not wetted by water. Let this tube be plunged into a bath of water. Then, as is well known, the water will not rise to more than a certain height in the tube, the conditions being as represented in Fig. 6. Let h be the amount in centimetres by which the water is depressed. Let r be the radius of the meniscus and σ the surface tension of the film A B C expressed in dynes per cm. Then the tension in this film will suffice to balance a pressure of $\frac{2\sigma}{r}$ dynes per square centimetre. This is easily seen on considering the resistance of a complete spherical shell to an internal pressure.

FIG. 5.

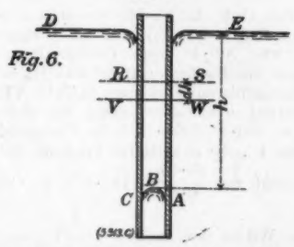


Fig. 6.

Let p be the pressure of the vapour immediately above the meniscus and P the pressure due to the head h acting below the meniscus; then, as this meniscus remains in equilibrium, we have

$$p + \frac{2\sigma}{r} = P.$$

At the upper level surface of the liquid D E the pressure is simply the saturation pressure p_s, due to the temperature of the liquid. Hence we may write

$$p - p_s + \frac{2\sigma}{r} = P - p_s = P - P_0 \quad . \quad (10)$$

Since P_0, the pressure at the surface of the liquid, is equal to p_s.

Now (10) may be written in the form

$$\frac{2\sigma}{r} + \int_{p_s}^{p} dp = \int_{P_0}^{P} dP$$

Consider a little layer taken right across the figure, at the level R S. Then, in passing down to the level V W, situated at a distance dh below R S, the water pressure increases by the amount $G\,dh$, and the vapour pressure by the amount $\gamma\,dh$, where G denotes the weight of 1 cub. cm. of water and γ the weight of 1 cub. cm. of vapour.

Hence

$$dP = G\,dh \text{ and } dp = \gamma\,dh$$

$$\therefore dP = \frac{G}{\gamma}.dp.$$

$$\therefore \frac{2\sigma}{r} = \int \frac{G}{\gamma} dp - \int dp$$

$$= \int_{p_s}^{p} \left(\frac{G}{\gamma} - 1\right) dp$$

In general, the weight of 1 cub. cm. of steam is very small compared with that of 1 cub. cm. of water, so that $\frac{G}{\gamma}$ is a large quantity.

Hence, approximately, we get

$$\frac{2\sigma}{r} = \int_{p_s}^{p} \frac{G}{\gamma}\, dp$$

If we take G as constant, this gives

$$\frac{2\sigma}{r} = G \int_{p_s}^{p} \frac{dp}{\gamma} = G \int_{p_s}^{p} V dp$$

since V, the volume of 1 gramme of vapour, is equal to $\frac{1}{\gamma}$, where γ is the weight in grammes of 1 cub. cm.

From the ordinary gas equation $pV = RT$ where T is the absolute temperature (Centigrade) and R a constant. Hence

$$\frac{2\sigma}{r} = RTG \cdot \int_{p_s}^{p} \frac{dp}{p} = RTG \log_e \frac{p}{p_s}$$

Since G = 1 gramme we get finally

$$\log_e \frac{p}{p_s} = \frac{1}{RT} \cdot \frac{2\sigma}{r} \quad . \quad . \quad . \quad (11)$$

Here p denotes the pressure in equilibrium with a drop of radius r, and p_s denotes the saturation pressure due to the temperature of the drop.

In his experiments on the expansion of dust-free but saturated air Mr. C. T. R. Wilson found that a fine mist formed when $\frac{p}{p_s}$ was equal to about 8.

From this value for $\frac{p}{p_s}$ Callendar (Enc. Brit., Vol. xxvii., page 899) deduces that r is equal to 5×10^{-8} cm. This quantity is of molecular dimensions, and it is natural to conclude that the nuclei involved are the double or co-aggregated molecules which are known to exist in steam, and in truly stupendous numbers, presenting in the aggregate an enormous surface. It is not suggested that these co-aggregated molecules are actually spherical in form, but merely that considered as nuclei they are equivalent to spheres of the radius stated.

For our present purpose we are merely concerned to note that r is constant, so that equation (11) may be written as:

$$\log_{10} \frac{p}{p_s} = \frac{3.75\,\sigma}{T}$$

Lord Rayleigh (Enc. Brit., vol. v, page 275) quotes Wolf's formula for σ as:

$$\sigma = 76{\cdot}08\,(1 - 0{\cdot}002\,t + 0{\cdot}000{\cdot}004{\cdot}15\,t^2) \text{ dynes per sq. cm.}$$

where t denotes the temperature on the Centigrade scale.

* ENGINEERING, January 10, 1913, page 38

† "Heat," by James Clerk Maxwell. Edition of 1880, page 290.

The following table shows the corresponding values of $\frac{p}{p_s}$ for different temperatures :—

t	$\frac{p}{p_s}$	t	$\frac{p}{p_s}$	t	$\frac{p}{p_s}$
0	11.08	40	6.987	80	5.014
10	9.727	50	6.367	90	4.685
20	8.632	60	5.841	100	4.300
30	7.732	70	5.395	110	4.152

The table shows that if steam is expanded until its temperature falls, say, to 40 deg. C., there will be no condensation of the steam unless the pressure is 6·987 times that of saturated steam at the same temperature. At 40 deg. C. saturated steam has a pressure of 1·0703 lb. per square inch. So that no condensation will occur unless the pressure of the steam exceeds $6{\cdot}987 \times 1{\cdot}0703 = 7{\cdot}478$ lb. per square inch.

This fact is sometimes expressed by the statement that the density of the supersaturated steam, when on the verge of condensing at 40 deg. C., is about 7½ times as much as it ought to be. Whilst quite correct, this way of presenting the facts is possibly likely to be misleading, and to convey the impression that the specific volume of the supersaturated steam is only $\frac{1}{7{\cdot}5}$ of what it would be, had the expansion taken place in conditions of thermal equilibrium. As a matter of fact, at 40 deg. C. the volume of the supersaturated steam in the conditions stated is 29·73 cub. ft. per pound, whilst if it then condenses and re-establishes thermal equilibrium the volume of the wet steam will be 32·67 cub. ft. per pound, so that looked at in this way the density of the supersaturated steam is only 10 per cent. more than it should be.

From the values of $\frac{p}{p_s}$ above tabulated we can get the pressure at which supersaturated steam at different temperatures condenses, and from Callendar's equations we can then get both the corresponding volume of the steam before this condensation occurs and also its total heat. These quantities are tabulated in Table VI, together with the temperature t_s attained if thermal equilibrium is established, and the corresponding specific volume y V_s. The last line in the table gives the entropy of the steam just before the condensation occurs. It has been calculated from Callendar's equation.

$$\phi = 1{\cdot}09876 \log \frac{T}{273{\cdot}1} - 0{\cdot}25356 \log \frac{p}{14{\cdot}669} - \frac{0{\cdot}1444\,p}{T}\left(\frac{273{\cdot}1}{T}\right)^{\frac{10}{3}} + 1{\cdot}76300$$

TABLE VI.—*Properties of Steam at the Wilson Line.*

Temperature at Wilson Point.	Pressure at Wilson Point.	Volume at Wilson Point.	Total Heat at Wilson Point.	Equilibrium Temperature.	Equilibrium Volume.	Entropy at Wilson Point.
t_w	p_w	V_w	H_w	t_s	$y\,V_s$	ϕ_w
deg. C.	lb. per sq. in.	cub. ft. per lb.	F.P.C.	deg. C.	cub. ft. per lb.	
0	0·8938	295·30	593·79	28·52	325·85	1·9086
10	1·739	173·33	598·28	49·41	191·50	1·8641
20	2·935	106·11	602·64	60·33	116·91	1·8220
30	4·764	67·439	606·85	71·19	74·218	1·7825
40	7·478	44·091	610·90	82·13	48·474	1·7476
50	11·39	29·732	614·75	93·00	32·666	1·7141
60	16·86	20·566	618·36	103·89	22·575	1·6830
70	24·36	14·531	621·70	114·80	15·957	1·6537
80	34·41	10·506	624·56	125·66	11·537	1·6261
90	47·60	7·720	627·47	136·57	8·638	1·5998
100	64·64	5·778	630·01	147·48	6·353	1·5748
110	86·28	4·389	632·10	158·40	4·852	1·5508
120	113·37	3·376	633·89	169·43	3·713	1·5278

The figures in the last column and in column 4 were used in plotting the Wilson line of the steam chart reproduced in Plate I *ante*.

The cumulative heat drop, or effective thermodynamic head due to an expansion without condensation down to the Wilson line and with subsequent expansion in conditions of thermal equilibrium can be worked out in almost exactly the same way as was done when the expansion was assumed to take place in conditions of thermal equilibrium throughout.

TABLE VII.—Cumulative Heat Drop when Expansion Takes Place without Condensation Down to the Wilson Line, and then Proceeds in Conditions of Thermal Equilibrium Down to a Final Pressure of 1 Lb. Absolute. The Initial Conditions Assumed are:—Stop-valve pressure, 195 lb. absolute; initial pressure, 180 lb. absolute.

Stop-valve superheat .. .. deg. F.	0.	50.	100.	150.	200.	250.	300.
$\eta = 0{\cdot}5$ $U'_{0\cdot5}$ before condensation .. F.P.C.	105·16	164·20	214·35	227·72	241·03	253·88	266·96
U_s after condensation	91·08	40·34	—	—	—	—	—
$U_{0\cdot5} = U' + U_s$	197·24	204·54	214·35	227·72	241·03	253·88	266·96
$\eta = 0{\cdot}6$ $U_{0\cdot6}$ before condensation .. F.P.C.	77·06	118·85	158·36	195·07	228·50	240·68	253·09
U_s after condensation	117·94	82·78	51·13	23·48	—	—	—
$U = U' + U_s$	195·02	201·63	209·49	218·55	228·50	240·68	253·09
$\eta = 0{\cdot}7$ $U'_{0\cdot7}$ before condensation .. F.P.C.	61·12	93·56	124·69	154·41	182·68	207·70	235·71
U_s after condensation	131·03	104·91	80·99	59·07	39·26	21·42	4·75
$U = U' + U_s$	192·15	198·47	205·68	213·48	221·94	229·12	240·46
$\eta = 0{\cdot}8$ $U'_{0\cdot8}$ before condensation .. F.P.C.	50·93	77·41	102·67	127·71	151·45	174·39	196·60
U_s after condensation	138·23	117·79	99·09	81·37	65·25	50·33	37·05
$U = U' + U_s$	189·16	195·20	201·76	209·08	216·70	224·72	233·65

With $\eta = 0{\cdot}5$ there is no condensation with a back pressure of 1 lb. and a stop-valve superheat of 97·45 deg. F. The corresponding value of $U'_{0\cdot5}$ is 213·41.
With $\eta = 0{\cdot}6$ there is no condensation with a stop-valve superheat of 197·91 deg. F. The corresponding value of $U'_{0\cdot6}$ being 228·06 ft.-lb. Centigrade units.

If we take Callendar's expression for the adiabatic expansion of steam, viz. :

$$p\,(V - b)^{1\cdot3} = \text{constant}$$

then the law of expansion at an hydraulic efficiency η is :

$$p\,(V - \frac{\lambda}{\gamma}b)^{\lambda} = \text{constant}$$

where

$$1 - \frac{1}{\lambda} = \eta\left(1 - \frac{1}{\gamma}\right)$$ (see page 53 *ante*)

γ being the adiabatic index and b having for steam the value 0·01602 cub. ft. per pound.

From Table VI we note that corresponding to the temperature $t_w = 30$ deg. the volume V_w is 67·439, whilst P_w is 4·764. Assume that this condition has been reached after an expansion from 180 lb. absolute with an hydraulic efficiency of 0·6. The value of λ corresponding to this efficiency is given by :

$$1 - \frac{1}{\lambda} = 0{\cdot}6\left(1 - \frac{1}{1{\cdot}3}\right) = 0{\cdot}6 \times 0{\cdot}23077$$

$$\therefore \lambda = 1{\cdot}1607$$

Hence :

$$\frac{\lambda}{\gamma}b = \frac{1{\cdot}1607}{1{\cdot}3000} \times 0{\cdot}01602 = 0{\cdot}0134$$

so that :

$$\left(V_w - \frac{\lambda}{\gamma}b\right) = 67{\cdot}326$$

Let V′ be the original volume at 180 lb. pressure ; we then have :

$$180\,(V' - 0{\cdot}013)^{1\cdot1607} = 4{\cdot}764 \times (67{\cdot}326)^{1\cdot1607}$$

This gives :

$$V' - 0{\cdot}013 = 2{\cdot}946$$

and

$$V' = 2{\cdot}959 \text{ cub. ft. per lb.}$$

Hence from Callendar's tables the original temperature was 245·4 deg. C., and the original total heat H′ was 700·40 ft.-lb. Centigrade units. At the Wilson line the heat content was $H_w = 606{\cdot}85$, ft.-lb. Centigrade units, as given in Table VI. Hence the external work done down to this line is $700{\cdot}40 - 606{\cdot}85 = 93{\cdot}75$ ft.-lb. Centigrade units, and hence U′, the cumulative available heat down to this point, was $\frac{93{\cdot}75}{0{\cdot}6} = 155{\cdot}9$ ft.-lb. Centigrade units.

At the Wilson line condensation occurs, and on our present hypothesis thermal equilibrium is established with a corresponding increase of entropy and the thermal equilibrium is maintained during the rest of the expansion down to 1 lb. absolute. By direct calculation or from the chart, Plate I *ante*, it is easily found, in the usual way, that the adiabatic heatdrop corresponding to this part of the expansion is $u_x = 52{\cdot}2$ ft.-lb. Centigrade units. Since x has the value 4·764 the reheat factor corresponding to $\eta = 0{\cdot}6$ is, from Table III, $R_x = 1{\cdot}0197$.

Hence U_x, the cumulative heat which becomes available during this part of the expansion, is 53·1 ft.-lb. Centigrade units. The total cumulative heat drop including both parts of the expansion is

$$U = U' + U_x = 209.0 \text{ F.P.C.}$$

Proceeding in this way the values of U′ and U_x can be found for various initial superheats and different hydraulic efficiencies, and by interpolation we get then the results given in Table VII.

According to the "Beama" tables, with a stop-valve pressure of 195 lb. absolute and a stop-valve super-heat of 150 deg. F. the consumption is $\frac{1}{1{\cdot}16}$ times as much as with no superheat.

As before, let us assume that with a superheat of 150 deg. the hydraulic efficiency of the turbine is 0·7. Then we can calculate, as already shown, the theoretical consumption with no superheat.

Thus, assuming the ratio of blade speed to steam speed remained constant, the value of U with no superheat would from Table VII be 192·15 ft.-lb. Centigrade units.

From the curve, Fig. 4, page 107 *ante*, however, the value of $\frac{K}{U}$ will be increased from 580 to

$$\frac{580 \times 213{\cdot}48}{192{\cdot}15} = 645.$$

This from the curve corresponds to an hydraulic efficiency of 0·72. Hence, interpolating in Table VII, the corrected value of U for no superheat is 191·55 ft.-lb. Centigrade units. The change in efficiency due to this small correction is negligible, so that the relative consumptions with no superheat and with 150 deg. superheat (at the stop valve) will be in the ratio $0{\cdot}7 \times 213{\cdot}5$ to $0{\cdot}72 \times 191{\cdot}6$, *i.e.*, as 1·00 to 1·082. The experimental figure as given by Baumann is 1·160 to 1. Hence this modification of the ordinary theory will not account for the facts. In the foregoing reduction we have used the curve Fig. 4, but of course, in strictness, the efficiency should be one plotted on the same assumption as adopted in the rest of the calculation. The point, however, is immaterial in the present instance.

(To be continued.)

Electric-Resistance Changes in Annealed Steels.—Some new experiments on the changes of electric resistance, produced in hardened carbon steels by their being annealed, are described by Professor I. P. Parkhurst, of Kansas University, in the *Journal of Industrial and Engineering Chemistry* of July, 1918 (pages 515 to 518). The method was to quench the steels (from 1,000 deg. C.), determine their resistance, anneal them at a definite temperature, redetermine the resistance and repeat the procedure at the same temperature, but at increasing time intervals, the total period of annealing aggregating from 90 up to 190 hours. Such series were taken at four different temperatures. The specimens used were coils of wire, about 50 cm. in length, prepared from steel bars which were first forged down to ¼ in. and then drawn (in sections about 4 in. long) to diameters of 0·014 in. or 0·019 in. The generating and annealing was effected in a tubular silica vacuum furnace. In order to avoid oxidation the heating of the coiled wire was effected within a few minutes. The temperatures adopted were 125 deg. C., 150 deg. C., 175 deg. C., 250 deg. C. The first three temperatures were produced by means of a paraffin bath, into which the coil was lowered, directly or sheathed with a small glass tube ; the highest temperature was produced in an electric oven. The bath and oven were constant within 1 deg. C. or 5 deg. C. The electric resistance were determined by the Kohlrausch bridge method in a thermostat, constant within 0·05 deg. C. The carbon percentage of the steels tested ranged from 0·05 deg. C. up to 0·45 deg. C. The resistance decreased in all cases together with the hardness, rapidly at first and then very slowly. The larger part of the change took place in the first few minutes, but the diminution of the resistance was not entirely complete within 113 hours, and probably not at the end of the maximum period of 190 hours. There was, apart from the initial fall of the resistance, very little change in the resistance of the low carbon steels.

ALUMINIUM (BAUXITE) DEPOSITS AND THE PRODUCTION OF ALUMINIUM.

Although it is impossible, at the present moment, to forecast the effect of the war upon many industries it is clear that the shortage of copper has greatly extended the use of aluminium, and that not merely temporarily. The production has in consequence increased and a number of important aluminium works have been, and are being, started in different countries. Under these circumstances a survey of bauxite deposits, more especially the less-known ones, and a description of the development and present state of the processes of production, may be of some interest.

During the war the Hungarian bauxite deposits have attracted considerable attention, as they are likely to play an important part in the Central European production of aluminium in the future. In the southern portion of Bihárhegyzég, in the Galbina Valley, and in the districts of Petrosz and Sykerisora, there are bauxite deposits, principally of the jurassic period, and consisting of irregular knolls. In the year 1905 Szadeczky demonstrated the existence of seven substantial layers, and three years later the number of known layers had increased to 18. The contents have been estimated at 1,000,000 tons. Bauxite is also found in the northern part of Bihárhegység, at Jádvölgy, in limestone of the jurassic period; there are some seven layers with a content of 350,000 tons. Similar deposits are found in Bihármegyei Királyerdö; they have been examined by several experts and their capacity has been estimated differently, from 6,000,000 tons to 18,000,000 tons, a German expert putting it at 12,000,000 tons. In addition there are important deposits in the Possieior Hodisanulu district, in the southern part of Királyerdö, the capacity of which has been valued at 7,200,000 tons. These figures, which are those of the German expert Paul, have by others been considered somewhat excessive. Bauxite is also found in the Gracac district, Croatia, also in limestone or on limestone. The quantity here is estimated at 1,000,000 tons. Further, bauxite deposits are located in Dalmatia, in the southern Velebit Mountains, but the quantity has not yet been ascertained, as is also the case with some deposits in Bosnia, in the Studenovzelo district at Mortar. Bauxite deposits in limestone mountains are found in Serbia, in the neighbourhood of Badujévács, in the Kragujévácz district.

To complete the account we append some particulars about the bauxite deposits, generally better known, in other countries. In Austria such deposits are met with in Krain, in the Wocheim-Feistritz district, also in Styria and the Tyrol. In Germany, in the Grand Duchy of Hesse, in and about the Vogelsberg Mountains, where bauxite is come upon in small lumps, varying in size from quite small pieces to those the size of one's head. In Italy in the Appenines at Abruzzo and Ferra di Livoro. In France, in the departments of Var (Toulon) and Bouches de Rhône (Beaux); in Ireland, especially at Belfast; in India and in tropical countries generally; in the United States, in the districts of the river Alamba, in Georgia, where the bauxite takes very irregular shapes, together with limestone and dolomite of the Silurian period.

The annexed table contains particulars of the chemical composition of various kinds of bauxite. These are the outcome of some 150 analyses undertaken by M. Bélo Horváth, and refer both to good and inferior kinds, for comparison's take. It will also be evidenced by the table, that it is scarcely correct to speak of pure and impure bauxite, as the composition varies so greatly; it is rather a question of bauxite technically exploitable or otherwise. The bauxite from the Hungarian Bihar committate is of a fairly satisfactory quality, and with the present methods aluminium can be extracted with remunerative results, the more so as cheap water power is available. The Bihar bauxite, however, contains, in some cases, at least, silicic acid, which is detrimental to the production of aluminium, as even 2 per cent. makes the aluminium brittle. In addition, silicic acid, in combination with sodium, enters into combination with aluminium in the form of a complicated sodium-aluminium-silicate (probably sodium-aluminium-orto-silicate, $NaAlSiO_4$)

Analyses of Bauxite from Various Sources.

District.	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	Loss on Ignition.	Other Substances.	Total.
Bihárhegység (Hungary).	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
1. East of Vaskóh	1·52	3·10	53·20	27·66	14·39	CaO, 0·20; MgO, trace	100·07
2. Poatra Galbina	1·52	1·95	58·26	30·22	8·09	MgO, 0·09	100·13
3. Right of the Izvor	2·84	3·15	55·91	28·09	10·42	CaO, 0·10	100·51
4. Fäcza Arzs-tetö	6·69	3·10	58·70	19·23	11·80	CaO, 0·80	100·32
Királyerdö (Hungary).							
5. Rév	0·80	3·20	53·70	29·70	—	—	87·40
6. Beharrósa	1·62	1·15	60·83	25·82	11·31	—	100·73
7. Vércsorog	1·67	1·05	59·65	24·66	14·09	—	101·12
8. Cucuhegi Tiszaluh	12·38	3·95	58·74	7·84	16·31	CaO, 0·32; MgO, 0·11	99·65
Croatia.							
9. Rudopolje	6·30	—	66·02	14·82	12·70	—	99·84
10. Grgicnbrieg	10·29	—	50·61	26·89	11·29	—	99·08
11. Mazin	33·0	traces	38·37	19·85	8·11	CaO, 0·77	100·10
Dalmatia.							
12. Mosée	0·87	—	59·27	24·36	15·93	—	100·43
13. Ilvar	30·47	—	29·05	16·24	17·14	CaO, 6·79; MgO, trace	99·69
Bosnia.							
14. Studenovrselo	0·37	8·51	55·37	21·76	13·45	ZrO_2, 0·45	99·91
Austria.							
15. Sannthal	6·32	0·91	64·05	15·93	13·28	—	100·49
16. Feistritz	13·60	—	57·25	0·97	24·38	CaO, 1·80; P_2O_5, 1·40	99·40
Germany.							
17. Garbenteich	1·10	3·20	50·92	15·70	28·60	CaO, 0·80; MgO, 0·16	100·58
18. Firnewald	4·92	2·80	53·10	10·62	27·80	CaO, 2·62; MgO, traces	99·86
France.							
19. Thovonet (Var)	0·30	3·40	69·30	12·90	14·10	—	100·00
20. Allauch (Bouches-du-Rhone)	4·80	3·20	55·40	24·80	11·60	—	100·20
Ireland.							
21. Belfast, at Antrim ..	6·01	—	61·89	1·96	27·82	—	97·88
22. Belfast, at Antrim ..	15·05	—	43·44	2·11	35·70	—	96·30
North America.							
23. Georgia	6·62	1·05	64·91	0·28	33·53	—	100·39
24. Jacksonville, at Alabama	10·25	2·53	41·00	25·25	21·08	P_2O_5, traces	100·11
25. Jacksonville, at Alabama	21·08	2·52	48·92	2·19	23·86	P_2O_5, traces	98·57

Analyses Nos. 1, 2, 6, 7, 8 and 15 have been undertaken by B. Horváth; Nos. 3, 4, 21 and 22 by E. Apor; No. 5 by Schelle; Nos. 9, 11, 12 and 14 by Tucan; No. 10 and 13 by Krmpotic; No. 16 by Henatsch; Nos. 17 and 18 by Liebreich; No. 19 by Augé; No. 20 by Deville; No. 23 by Watson; and Nos. 24 and 25 by Hillebrand.

which will not dissolve and makes part of the aluminium useless. If this formula is correct, it is seen that 100 parts of silicic acid will bind 84·74 parts (weight) of oxide of aluminium (Al_2O_3), which represents 44·94 parts of alumina, or 17·85 per cent of the aluminium contained in the bauxite in question. This naturally increases the cost of production and detracts materially from the remunerative results, rendering it unprofitable to use such bauxite. The percentage of silicic acid in certain varieties of bauxite averages 1·36, that of alumina 30·76. The silicic acid will bind 0·61 per cent. of alumina, so that only 1·98 per cent. of the aggregate quantity of alumina will be lost; this is such a small quantity that it is permissible, and those qualities of bauxite are consequently well suited for aluminium production.

Aluminium figures as third in the list of elements of the body of the earth (7·90 per cent. according to F. W. Clarke) and as No. 1 of all the metals (iron comes next with 4·43 per cent.). Kaolin, clay and many minerals contain considerable quantities of alumina. The first important step towards the production of aluminium was made by the famous Danish scientist H. C. Örsted, who succeeded in producing chloride of aluminium, and also attempted to reduce it by means of potassium. Wöhler, in 1827, repeated Örsted's experiments, working with chloride of aluminium and metallic potassium. The result was only aluminium in the shape of a grey powder, and it was not till 18 years later, in 1845, that Liebig could announce he had succeeded in producing aluminium in globules as big as a pin's head. It was, however, St. Claire Deville who first succeeded in producing aluminium industrially, using the cheaper sodium and the more stable chloride of aluminium.

Several factories were built to work on the St. Claire Deville method, of which the one at Salindres produced 2½ tons of aluminium annually. The production increased only slowly to begin with, as will appear from the appended table, showing the aggregate output in tons:—

1880	...	2·4	1905	...	13,200
1885	...	13	1906	...	17,200
1890	...	175	1907	...	20,200
1895	...	1,426	1908	...	26,600
1900	...	5,000	1909	...	34,400
1901	...	6,900	1910	...	40,700
1902	...	8,350	1911	...	54,100
1903	...	9,600	1912	...	65,200
1904	...	10,600	1913	...	76,500

It was not till the price of sodium gradually declined from 2,000 francs to 15 francs per kilogramme, that the cost of aluminium began to decrease; the following table shows the immense reduction in price:—

	£ per ton.
1854	120,000
1855	48,000
1856	14,400
1858–85	4,800
1886	3,400
1888	2,300
1890, commencement	1,320
1890, close of year	720
1891, commencement	600
1891, close	240
1895	145
1900	86
1905	120
1910	62
1915, January	80
1915, July	140

In 1886 a commencement was made with the electrolytic production of aluminium, and parallel with the development of this process prices fell rapidly; in the course of six years from 5,000*l.* per ton to 250*l.* During the years prior to the war the quotation dropped right down to 60*l.* per ton, so that aluminium had become one of the cheaper metals.

It was not till the dynamo was available that Héroult and Kiliani made the production of aluminium a remunerative industry, and most aluminium works in Europe still use Héroult's electrolytic method, whilst in America Hall's method is mostly followed. M. Héroult had, in 1887, constructed a technically serviceable furnace for the production of aluminium by means of electrolysis (Fig. 1, page 164), really on the principle laid down by Bunsen. Both these methods employ bauxite as the raw material.

Besides bauxite proper ($Al_2O_3\ 2H_2O$) there is the less frequently found diaspore ($Al_2O_3H_2O$) and the Gibbsite ($Al_2O_3 3H_2O$). The principal constituents of bauxite are oxide of aluminium (Al_2O_3), oxide of iron (Fe_2O_3), silicic acid (SiO_2) and water. There are frequently also other ingredients, for instance, titanic acid, and according to these various ingredients the bauxite assumes different colours, mostly, however, a reddish brown, although the colour may vary considerably.

Dr. Béla Horwith gives as the average values of 150 different samples of bauxite from different parts of the world, the following figures:—

Substances always found:	Per Cent.
Al_2O_3	9·05 to 76·90
Fe_2O_3	0·10 to 58·02
SiO_2	0·30 to 58·03
H_2O	5·85 to 35·70
Substances sometimes found:	
TiO_2	0 to 12·21
ZrO_2	0 to 2·71
CaO	0 to 8·24
MgO	0 to 1·32
K_2O	0 to 0·32
Na_2O	0 to 1·36
P_2O_5	0 to 1·50
SO_3	0 to 0·49
CO_2	0 to 6·26
Mn	0 to traces
Li	0 to traces
V	0 to traces

In the production of aluminium the reddish-brown bauxite is now principally used, but as it is necessary to employ pure oxide of aluminium for the production of aluminium having a purity of 98 per cent. to 99·5 per cent. the bauxite must first be refined. If bauxite is used without being refined, the other metallic oxides it contains are also reduced and the result is an aluminium alloy. The manufacture of oxide of aluminium necessitates special works which, from considerations of transport, should be placed in the vicinity of the bauxite deposits, and where fairly cheap coal can be obtained.

What the cost of transport may amount to will appear from a few figures from the Salindres factories, which have an annual production of some 12,000 tons of oxide of aluminium, and for which production 30,000 tons of bauxite, 6,500 tons of lime and 50,000 tons of coal are needed.

To obtain pure oxide of aluminium the raw material must first be transformed into soluble sodium aluminate, and at the same time the impurities must be kept insoluble. Two different methods are used, the dry process, the so-called Deville-Pechiney process, and the wet process, the so-called Bayer process.

In the dry process the finely-ground bauxite is mixed with soda in accurately-weighed quantities, so that there is the right proportion between the sodium-oxide and the oxide of aluminium. The mixture is placed in a roasting furnace where it is heated to a temperature of some 1,100 deg. C. The roasting occupies 4 hours, during which the carbonic acid is removed from the soda, and the sodium enters into combination with the oxide of aluminium. The product is a greyish-brown substance. During the process it loses some 25 per cent. of its weight, and the product is then lixiviated with boiling water, whereby the sodium aluminate is dissolved, whilst the oxide of iron and the oxide of titanium, being insoluble, are separated. During the roasting a small portion of the silicic acid is transformed into sodium silicate; and passes into the solution, but the rest, the greater part, of the silicic acid, which is insoluble, is separated.

The lye then passes through filter presses, and the residue, consisting principally of oxide of iron, is sold to the gas works, where it is used in the purifiers. The lye leaving the filters contains a small portion of the silicic acid, about 3 parts SiO_2 to 100 parts Al_2O_3, dissolved as silicate of sodium. In order to remove this, the lye is heated in an autoclave to about 160 deg. C. under a pressure of 85 lb. per square inch, when the silicic acid is precipitated as an insoluble sodium-aluminium-silicate. The lye, when the residue has settled, is sufficiently free from silicic acid (it does not contain above 0·3 parts SiO_2 for 100 parts Al_2O_3) to be used for the production of oxide of aluminium, for the manufacture of aluminium.

Carbonic acid is blown into the heated lye and the aluminium hydrate is easily precipitated as a thick, grainy substance. The carbonic acid used for this process is generally produced in lime kilns The process yields very good results, both as regards the quantity and the purity of the product. There are, however, two by-products; the lime from the generation of the carbonic acid and the soda from the precipitation of the aluminium hydro-oxide. These are mixed, the result being caustic soda. The production of this by-product, however, entails inconveniences, so when the factories had to be materially enlarged the Bayer process was resorted to, it having the advantage of not being hampered by any auxiliary products.

In the Bayer process the bauxite is first crushed in an ordinary crushing mill and is subsequently ground in other mills, until sufficiently fine. It is then mixed with concentrated soda lye, and the mixture, by means of centrifugal pumps, is conveyed into the autoclaves, where it is heated, the autoclaves having steam jackets, under a pressure of seven atmospheres. The oxide of aluminium dissolves in the soda lye, whilst the impurities of the bauxite, Fe_2O_3 and TiO_2, are not affected. At the same time the SiO_2 forms an insoluble sodium-aluminium-silicate, so that there is no impurity from silica left in the lye. There are altogether 20 autoclaves at Salindres of 6,500 litres capacity each. The charge consists of 4,500 litres of sodium lye and 1,100 to 1,200 kilogrammes of bauxite.

The treatment in the autoclaves takes about eight hours, so that three charges in the 24 hours can be treated, or 3,300 to 3,600 kilogrammes of bauxite for the 24 hours. It is estimated that

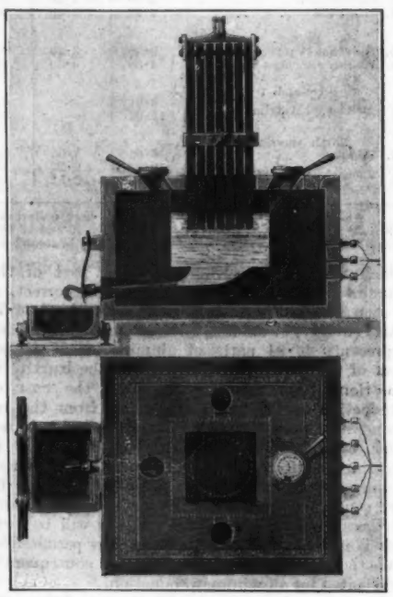


Fig. 1. Héroult Furnace for Producing Aluminium by Electrolysis.

85 per cent. to 88 per cent. of the oxide of aluminium in the bauxite is dissolved in the solution. As soon as the treatment in the autoclaves is finished, the lye is forced into iron reservoirs, of about 46 cub. metre (1,624 cub. f.) capacity and 5.80 m. height, of which there are eight. The lye in the autoclaves is at about 42 deg. Baumé, but in the reservoirs it must be diluted with water, or weak lye, to about 24 deg. Baumé. It then contains about 80 kg. of Al_2O_3 and 110 kg. of Na_2O per cubic metre, which corresponds with the proportion between the molecular weights of $1.2Na_2O$ to 1 Al_2O_3.

In five hours the solid ingredients settle to the bottom of the reservoirs, and the lye is siphoned into the decomposing vessels. The proportion between lye and residue is generally about 7 : 3. The lye, which is very nearly pure, having passed through filter presses, in order to be cleared of possible solid impurities, as already mentioned, is then conveyed into the decomposing vessels. It generally has a faint yellow colour from traces of chromium and vanadium. As soon as the lye has been siphoned off, the residue has water added and is pressed through large filter presses, where the solid substances remain, and the sodium-aluminate, which has been washed out of the residue, is secured in the solution. The weak lye thus obtained is used for diluting the next charge from the autoclaves. For cleansing the lye there are installed 3 filter presses with 24 frames, and for the cleansing of the residue 9 presses with 50 frames. The residue from the filter presses is worthless and is removed, for although it resembles the residue from the dry process, it cannot be used by the gas works. There is a possibility, however, that it can be used for extraction of iron or titanium, or used as red ochre colour, for which latter purpose both its colour and its structure should suit it.

The decomposing vessels are of 6 m. (19 ft. 8 in.) diameter and 6 m. height, and of about 170 cub. m. (6,000 cub. ft.) actual capacity. The installation at Salindres comprises 24 such vessels, equal to about 4,000 cub. m. of lye. The decomposing process takes place, because the combination of sodium-aluminate in the solution is not stable. Left to itself the solution, in a comparatively short time, will become muddy, and aluminium hydroxide will begin to disengage. The lack of stability increases in the same degree as the proportion between the oxide of aluminium and the sodium increases. The decomposition, which proceeds very slowly, when the solution is left undisturbed, is much accelerated by stirring, or by contact with already precipitated or added hydrate. This is one of the fundamental principles in the Bayer process. At Salindres the decomposing process generally extends over 48 hours, and about 60 per cent. of the oxide of aluminium is precipitated. After a few hours more, all the hydrate settles on the bottom of the vessel, from whence it is tapped, the mother lye first having been conveyed into the evaporator. A stock is left, as already mentioned, for affecting the next charge. The precipitation gives for each charge about 9,000 kg. to 9,500 kg. of hydrate. Five decomposing vessels are tapped every day, so the daily production amounts to 45 tons to 48 tons. The product is virtually free from iron and silicon and has a sandy appearance, the grains being somewhat smaller than those resulting from the dry process.

The latter part of Bayer's process is the concentration of the weak lye. The soda which is put into autoclaves at a density of 42 deg. Baumé is not, in principle at least, altered chemically. It contains in solution some Al_2O_3 which has adhered to it from the decomposing vessels, but that combines easily with the corresponding quantity of oxide of aluminium which it has parted from as soon as concentrated up to the original degree of concentration of 42 deg. Baumé. The evaporation of the water, which has been added during the precipitation and during the washing, takes place in two Kestner apparatus with triple effect. The evaporators are constructed in three sections, each with 139 pipes, representing about 152 sq. m. (1,636 sq ft.) of heating surface. The vertical pipe systems of the evaporators greatly favours the vaporising, and the installation works very satisfactorily. With a daily production of 45 tons of oxide hydrate, the evaporators dispose of about 460 cub. m. of water with a consumption of 230 tons of steam. The Kestner apparatus uses no less than two-thirds of the aggregate steam production of the works. The steam is supplied by two batteries of Babcock and Wilcox boilers, each of seven boilers with 150 sq. m. (1,614 sq. ft.) of heating surface, each with economisers of 189 sq. m. The boilers work at a pressure of 170 lb.

In the concentration of the diluted lye the sodium moves in a continuous cycle, so the same quantity of sodium, apart from the unavoidable losses, can be constantly used in the stock. To make up for what is lost, some sodium is added every day, and decarbonising is likewise attended to by addition of lime as far as the caustic soda in the stock (which, by being in touch with the air has absorbed carbonic acid), is concerned.

The aluminium-hydroxide resulting from both processes contains some 50 per cent. of water, partly in chemical combination and partly as moisture. In order to obtain the anhydrous oxide the aluminium-hydroxide has to undergo calcination. The furnace used for this purpose is similar to the rotary furnace used in the cement industry. It has a diameter of 2·25 m. (88 in.) and is 42 m. long, being lined with fire brick. The furnaces are placed in an inclined position on a grade of 2 per cent. The maximum temperature at the delivery end of the furnace amounts to about 1,350 centigrade to 1,400 centigrade. This temperature is necessary

for driving out the last remnant of moisture and to prevent the product from afterwards absorbing moisture from the atmosphere, and is obtained by producer gas and air heated to 700 deg. C.

The furnace can easily produce about 35 tons of pure oxide of aluminium per day, equal to about 70 tons of aluminium–hydroxide. The installation therefore only comprises one furnace of this type. The consumption of coal is some 13 tons to 14 tons, or in weight about 40 per cent. of the finished product, and the coal is gasified in producers with rotating grates.

So as to reduce the loss by dust formation during the calcining, there is a dust-catching plant inserted between the furnace and the chimney. It consists of four dust chambers, one ventilator and a pipe, in which the remaining dust is laid with water, injected through small holes.

The calcined substance is conveyed from the furnace through a cooling drum of 1·20 m. (47 in.) diameter and 23 m. length. This drum is likewise inclined (3·5 per cent. gradient) and rotates at the rate of 2·5 r.p.m. After leaving the cooling drum the oxide of aluminium is sifted and packed in bags ready for despatch to the aluminium works.

Both with the Deville and the Bayer methods of working it is a necessary condition that the bauxite used shall contain only a small percentage of silicic acid, inasmuch as the latter entails, as already stated, a loss of aluminium, by the insoluble aluminium–sodium silicate (Na_2O, Al_2O_3, SiO_2 + $9HO_2$) which is formed in the sodium lye. In French bauxite, with 60 per cent. Al_2O_3 and 3 per cent. SiO_2, 5 per cent. of the aluminic oxide is lost. By this separation of the silicon the percentage of Si in the final product does not exceed ½ per cent. Vergé obtains the same favourable result with bauxite containing twice as much silicon, requiring only a temperature of 125 deg. to 135 deg. C. in the autoclaves.

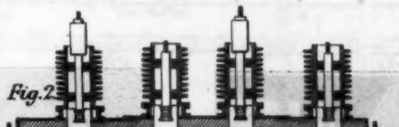
Peniakoff (Selzaête, Mennessia) produces aluminate, in a similar way as Deville–Pechiney, in a furnace and not by a wet process as is done by Bayer and Vergé. Peniakoff uses a rotary furnace, 30 m. long, slightly inclined, and reduces at 1,200 deg. C. a mixture of bauxite and sulphate of soda ($Na_2SO_4 10H_2O$), whilst Deville–Pechiney only use soda. The sulphuric vapours, having been exposed to the atmosphere and steam, are again used in the production of sulphate of soda by passing them over salt. The muriatic acid formed is collected as a by-product. The process is then continued as with the Bayer process.

White bauxite, which contains as much as 25 per cent. of silicic acid, but only 5 per cent. of oxide of iron, is treated in an entirely different way from red bauxite. It is finely ground and slightly heated so as to make it more porous. Warm sulphuric acid, specific gravity 1·25, is then carefully added to the bauxite, the result being aluminium sulphate. Steam and water are added, until the specific gravity becomes 1·2. The iron is dissolved as ferro and ferri-sulphate, together with the aluminium sulphate. If the bauxite also contains magnesium this, too, is dissolved. Having ascertained that there is no sulphuric acid left, the silicic acid is separated. The iron can be removed in various ways, either before being dissolved, by means of oxalic acid, or later by the aid of ferrooxyancalcium or sulphur–calcium. The solution of sulphate of aluminium is vaporised and the sulphate is calcined in carbonating furnaces, sulphuric tri- and di-oxide escaping; they are again transformed into sulphuric acid. The aluminate remains, and can be used direct for the production of aluminium.

Hall, in America, together with the Pittsburgh Reduction Company, now the Aluminum Company of America, has used a more direct method for the purifying of the bauxite. He employed electric arc furnaces, constructed like carbide furnaces. The bauxite is first calcined and mixed with 10 per cent. to 15 per cent. of coal, according to its degree of purity. By the temperature of the electric furnace the silicic acid is reduced, also the oxide of iron, and eventually the titanic acid, but also some of the aluminate. A very fusible alloy of iron, silicon, titanium and aluminium is formed which sinks to the bottom and is tapped off, forming a valuable by-product. This simple treatment is understood to be applicable to aluminates and silicates of aluminium, although the purified aluminate is not supposed to be as pure as with the chemical processes, nor will it so easily dissolve in the cryolite bath.

Cowles and Kayser have also used the electric furnace for the production of pure aluminate. At Sevaren, N.J., a tunnel furnace is being used; kaolin, felspar or aluminate are mixed with chloride of calcium in the proportion of 19 pure Al to 23·4 salt, 15 per cent. charcoal being added to accelerate the reaction. Briquettes of this composition, with some water added, are exposed to a temperature in the furnace equal to the volatilising temperature of the salt. The oxidising water vapours prevent the sodium from escaping, the outcome being a sodium–silicic acid–aluminate compound, and in addition muriatic acid; $2SiO_2Al_2O_3 + 4NaCl$ + water and carbon = $2SiO_2$, Al_2O_3, $2Na_2O + 4HCl$ + water and oxide of carbon. The muriatic acid is condensed as 18 deg. Baumé; the salt and some chloride of aluminium are collected in chambers. The furnace is 50 m. long, the trollies 3·60 m. by 1·60 m., each with a capacity of 55 briquettes

The substance is then treated with lime, slaked or otherwise, in a rotary furnace, where the following reaction takes place: $2SiO_2Al_2O_3$, $2Na_2O + 4CaO$ = $2SiO_2CaO_2 + 2Na_2O + Al_2O_3$. A surplus of lime will form an insoluble lime-aluminate, whilst a deficiency of lime will result in part of the insoluble



sodium–silicic acid–aluminate compound remaining. The aluminate is decomposed by the sodium lye and is treated in the usual manner. The silicic acid–lime compound can be used as a by-product, as in the cement or glass industry. The muriatic acid can be used for production of the double chloride of aluminium and calcium, felspar being used in this connection. Cowles is of opinion that the production cost of metallic aluminium, by using this method, can be reduced by not less than 50 centimes per kilogramme; a statement, the accuracy of which is questioned by other experts. But the process, like Hall's, has the advantage, it appears, of not being confined to bauxite.

Dr. Serpek, prior to the war, was in a fair way of combining the manufacture of aluminium with that of ammonia. He had ascertained the great affinity of aluminium for nitrogen at high temperatures. Dr. Serpek and Badin worked with large rotary electric furnaces, where the aluminate was treated with coal and nitrogen gas at 1,600 deg. to 1,800 deg. C. By using catalysts such as iron and hydrogen, the reaction can commence at 1,300 deg. C. The furnace was lined with nitride of aluminium. Our illustration, Fig. 2, shows the central portion of one of the furnaces used; carbon discs are used as resistances, in eight columns, each about 1·2 m. long; they are coupled in series and take 10,000 amperes with 230-volt continuous current, with which they yield about 1,800 deg. C. in the furnace. The reaction takes place in this way:—

$$Al_2O_3 + 3C + N_2 = 2AlN + 3CO$$

This nitride of aluminium, with water under pressure in autoclaves, yields aluminate and ammonia:

$$2AlN + 6H_2O = 2NH_3 + Al_2O_3\,3H_2O.$$

The ammonia having been distilled, the oxide of aluminium can again be used in the furnace. If, on the other hand, it is desired to use the alumina for aluminium production, the nitride of aluminium is placed in soda lye, and the ammonia will escape in the course of 2 hours to 2½ hours at 2 atmospheres pressure. It can be used for the production of nitric acid, nitrate of ammonia or sulphate of ammonia. The further treatment of the aluminate takes place according to the Bayer method, but the treatment in the autoclaves is somewhat simplified. Dr. Serpek states that only 2 atmospheres are required, instead of 8 atmospheres. The process is shorter and the concentration only 20 deg. Baumé, instead of 40 deg. This Bayer nitride process therefore is stated only to cost 63 francs per ton of pure aluminate, instead of 126 francs by the Bayer process, exclusive of the cost of bauxite. In addition, ½ ton of nitrogen is fixed per kilowatt year, corresponding to 2 tons of aluminate. It is, however, advisable to wait for the result of the experiments with the aluminium-nitride furnace. The Société Generale de Nitrures is also working with ferro-aluminium, which has proved itself able to fix nitrogen endothermically. Badin, unfortunately, died not long ago, and Dr. Serpek is not likely to have been able to continue his work in Paris or at St. Jean de Maurienne.

(To be continued.)

CONVEYOR AT THE WELLPARK BREWERY, GLASGOW.

By G. F. Zimmer, A.M.Inst.C.E.

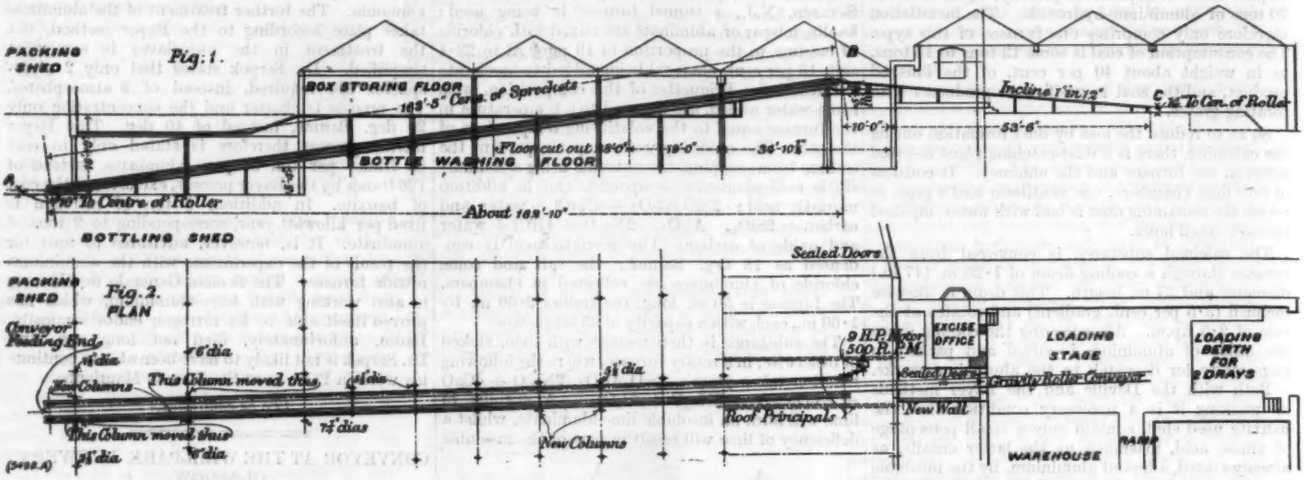
Most of the standard types of conveyors are well established, and at least their principles well understood, and have been for a comparatively long time, so that a new departure cannot fail to be of interest.

The principle involved is not in itself so much a novelty as a combination of two well-known methods, viz., that employed in the push-bar or drag-link conveyor, and the roller runway; this new hybrid bridges over the shortcomings and restrictions of the parent types. Let us look, for instance, at the push-bar or drag-link type of conveyor, a good machine in its way but with the limitation that it cannot be used economically for negotiating inclines except of the very slightest. If, on the other hand, we inquire into the merits of the roller runway we find that unless it is used on a downward gradient (to work by gravity) it has no claim to the name of conveyor, as the objects have to be pushed by hand in order to be conveyed. The "Gadget," or pusher, however, which has recently been brought into the market is a device for pushing cases along a roller runway in a continuous stream, each case pushing the next one forward, so that the boxes touch each other from end to end of the conveyor. Now a combination of these two principles furnishes us with a most valuable new conveyor for piece goods. It was first used in connection with roller runways when distances had to be covered by gravity which were too long for the available fall. In order to realise the situation better we must understand that the average incline for roller gravity runways is 4 to 5 per cent.; so if, for instance, tea chests have to be conveyed a distance of 100 ft. on such a conveyor there must be an available height of not less than 4 ft. for gravity to act efficiently as a conveying agent. If, now, we presume that these chests have to be conveyed a distance of 200 ft., and there is only 4 ft. of fall available, we may instal at the foot of the first run of 100 ft., one of these new, and as yet nameless, hybrids, the gravity runway track with its roller path being then continued for the remainder of the 200 ft., and all on an incline of 5 per cent. except the short connecting portion which is on the rising gradient. This short section raises the packages about 4 ft. to 5 ft., so that when they arrive at this higher level they are again free to continue the remainder of their journey by gravity. These short elevators are usually named "bumpers." As an alternative to this we may raise the packages by the new conveyor for an extra 5 ft.—in all 10 ft.—to begin with, and run the remainder of its length in one run by gravity. The speed at which the chain in these new conveyors is running, while assisting the packages up the hill, is just about the same as that at which they arrive at the foot of each descent, and by thus synchronising these motions, the dragging bars, which take hold of the packages, do so without any change in velocity, and thus avoid shock.

It is only within recent years that handling engineers have seriously begun to harness gravity as power and the integral part of a conveyor scheme, and it is probably owing to this fact that this new device was not called into being earlier. These runways are particularly attractive on account of the great economy effected by their use, since they require no driving power

GRAVITY CONVEYOR AT THE WELLPARK BREWERY, GLASGOW.

CONSTRUCTED BY THE HEPBURN CONVEYOR COMPANY, LIMITED, ENGINEERS, WAKEFIELD.



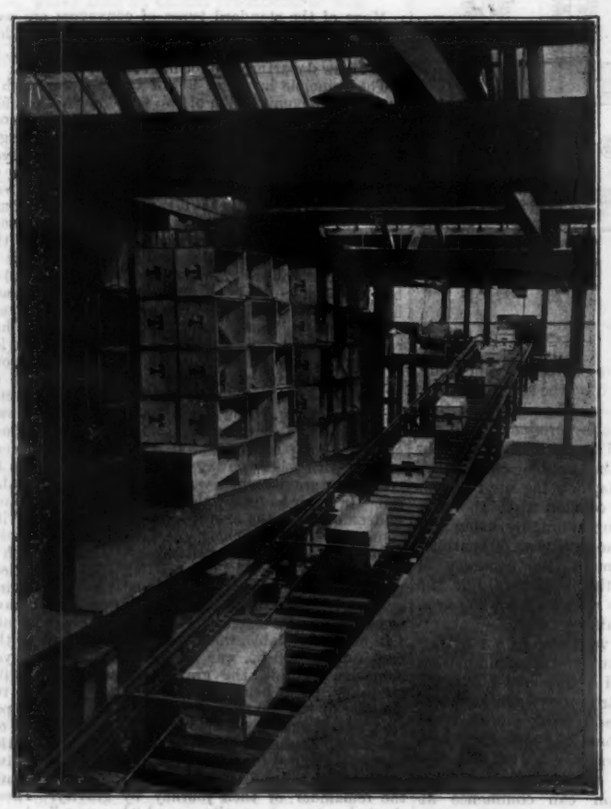


Fig. 3. Receiving End of Conveyor as seen from Point A, Fig. 1.

Fig. 4. Delivery End of Conveyor as seen from Point C, Fig. 1.

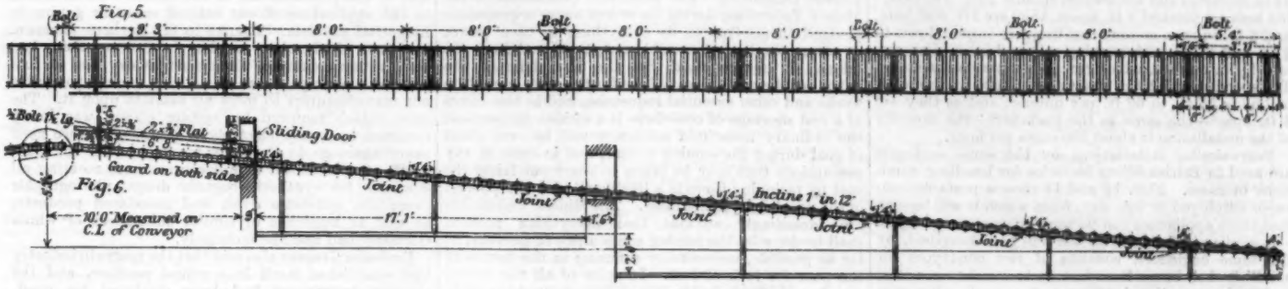
beyond that expended in raising the packages to the height necessary to secure the necessary running gradient on the descending portion of the line.

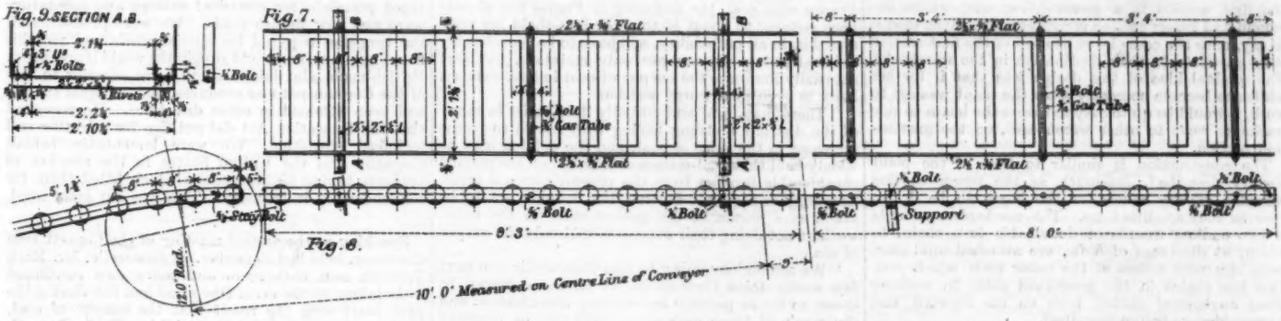
An interesting example of such a conveyor installation in which this system is applied is illustrated in Figs. 1 and 2; this installation is essentially one of a gravity conveyor in which the new appliance is merely a link, as pointed out. It was designed and erected for the Wellpark Brewery of Messrs. J. and R. Tennent, Limited, at Glasgow, by the Hepburn Conveyor Company, Limited, of Wakefield. It is for transporting export cases of bottled beer, weighing 3 cwt. each, a distance of 227 ft.; the difference in level between the feeding and discharging points being about 16 ft. The cases have to be fed on to the conveyor in the packing shed (see Fig. 2), and they have to traverse the bottle-washing department, where the path of the conveyor disappears through the ceiling into the box-store floor, which is 16 ft. 10 in. above the packing-shed floor and thence to the delivery point. Fig. 3 shows the power-driven part, and Fig. 4 the gravity delivery of the boxes at the other end. It will be understood that in the proposition before us it was necessary to elevate the boxes vertically for a distance of about 16 ft. in any case, and Messrs. Hepburn have, by making provision for raising the loads a few additional feet, provided sufficient energy for the cases to proceed under the action of gravity for the remainder of the distance, viz., 63 ft., which has a descending gradient of about 1 in 12. We may point out here that the gradient necessary on a line of this kind depends partly upon the character of the packages conveyed. With goods packed in well-finished cases a gradient of 1 in 20 will suffice.

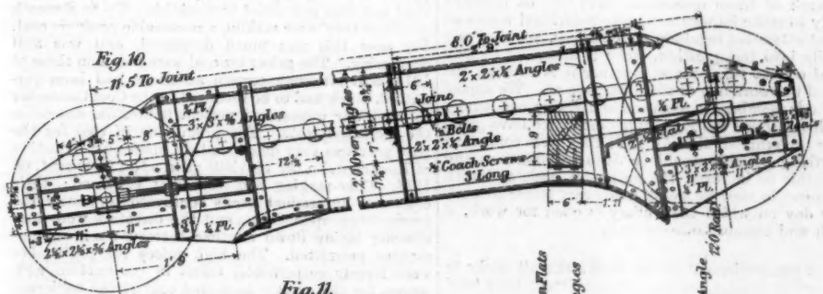
Before going into details of the installation we are illustrating we must point out that the boxes after they leave the starting point on their upward journey have to pass the Customs official. The section which they have to pass is a separate department into which the boxes enter and which they leave through openings in the wall; in this department is the excise officer's room, where there is a registering apparatus which records the number of cases that pass, and this section

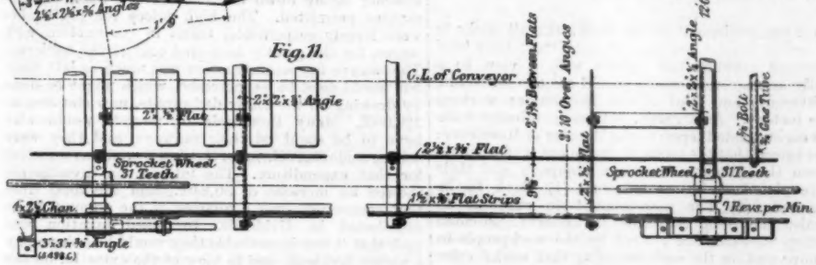
GRAVITY CONVEYOR AT THE WELLPARK BREWERY, GLASGOW.

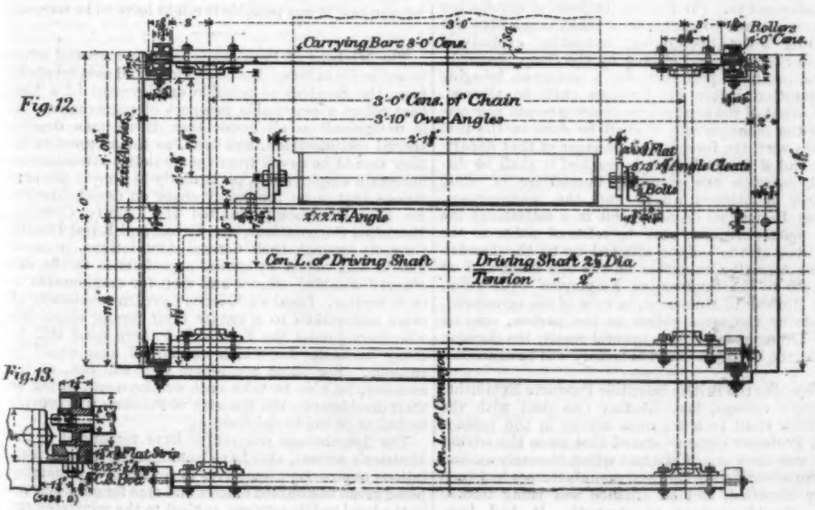
CONSTRUCTED BY THE HEPBURN CONVEYOR COMPANY, LIMITED, ENGINEERS, WAKEFIELD.











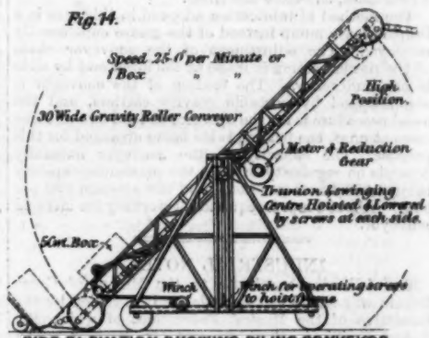
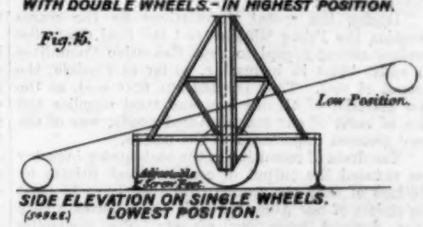


Fig. 14.
Speed 25 ft. per Minute or 1 Box " "
High Position.
30" Wide Gravity Roller Conveyor
Motor & Reduction Gear
Trunion & swinging Centre Hoistad & Lowered by screws at each side.
5 Cwt. Box
Winch
Winch for operating screws to hoist frame

SIDE ELEVATION SHOWING PILING CONVEYOR WITH DOUBLE WHEELS.—IN HIGHEST POSITION.



SIDE ELEVATION ON SINGLE WHEELS. LOWEST POSITION.

is only accessible to the excise officer. There are sealed doors on either side of this room to prevent ingress or egress of anything or anybody besides the officer in charge.

It will be seen from Fig. 1 that the cases are fed on at the foot of the incline at A, from which point they are raised up through adjoining buildings, and after leaving the power driven section at B they gravitate down to the loading berth at C. The whole roller runway is fitted from end to end with ball-bearing idlers about 22 in. long by 3¼ in. diameter, pitched at 8 in. from centre to centre. The mild steel frame is composed of 2½ in. by ⅜-in. flats, which are held in position by traverses about every 3 ft. 4 in. The views, Figs. 5 to 9, give details of the runway and the supports, they also show a space of 5 in. between the power-driven and the gravity section, which is sufficient for the pushing bars of the power-driven part to clear when passing the higher point.

The power-driven portion of the conveyor—which is about 163 ft. long from centre to centre—will be best understood from Figs. 10 and 11, which show the two terminals in elevation and plan. The two endless chains and the crossbars which push the boxes gradually

on their roller paths are best seen from a cross-section through the power-driven part, Figs. 12 and 13. The terminal sprocket wheels are 30 in. diameter at the pitch line, they have 31 teeth for No. 63 chain, and the speed is 7 r.p.m. to 8 r.p.m. The driving spindle is 2¼ in. diameter and the tension spindle 2 in. The carrying bars are pitched 8 ft. apart, they are 3 ft. 6 in. long, and 1 in. square, at each end they are turned down to ⅝ in. and fitted with running rollers 2 in. in diameter and 1¼ in. on face, which run on renewable flat strips. The speed at which the boxes are dragged up the roller incline is 55 ft. to 60 ft. per minute, and as they are 8 ft. apart—the same as the push-bars—the capacity of the installation is about 500 cases per hour.

Very similar installations by the same engineers are used in British filling factories for handling munitions in cases. Figs. 13 and 14 show a portable conveyor employed in this way, from which it will be seen that these appliances can be used at very steep angles.

A similar installation to the one just described, by the same engineers, consists of two conveyors for handling shell boxes from factory to warehouse, and is in use in a national filling factory. In this case the first section is a power-driven unit, whilst the second and longer section is entirely automatic, that is to say, once the cases leave the top of the first section they gravitate to their destination in the warehouse. The original idea of this design was that if further additions became necessary after the plant was set to work, it would be quite easy to divert the boxes to side tracks *en route* to other warehouses, on the gravitation section.

The construction is similar to that of the plant already described, inasmuch as the power section provides gravity rollers for the boxes to be drawn over as they are lifted up. The mechanism consists of two endless strands of detachable link chain, to which, at distances of 6 ft., are attached mild steel cross-bars with rollers at the outer ends which conduct the chains in the prescribed paths by working along angle-steel guides, both on the forward and return sides, as before described.

The method of lubrication adopted in this case is a simple grease pump instead of the grease cups usually employed. The adjustment of the conveyor chain of the power section is made at the lower end by slide blocks and screws. The feeding of the conveyor is accomplished by portable gravity carriers, and the usual procedure is for the operator to load two or three cases at once, the feeding table being arranged for this purpose. The capacity of the conveyor naturally depends on regularity of feed, the maximum capacity being 1,800 boxes per hour, and the average 600 per hour. About 5 h.p. is required for working the inclined conveyor.

INDUSTRIAL NOTES.

The following manifesto to the Miners of Great Britain was issued last Saturday. It is signed by the Executive of the Miners' Federation, of which Mr. Robert Smillie is President and Mr. Herbert Smith Vice-President:—

"During the recent negotiations on the wages question the Prime Minister and the Coal Controller made a strong appeal to your Executive Committee to assist them in increasing, as far as possible, the output of coal. They pointed out that coal, as the raw material of all our iron and steel supplies and also of most of our manufactured goods, was of the very greatest importance to the nation.

"The drain of recruiting in the coal-mining industry has reduced the output of coal in Great Britain by millions of tons per annum, while we have to meet the claims of our Allies for coal, which means a very large demand upon our exports. The Controller pointed out that during recent months the Germans had rendered unworkable a number of the French coal mines, and that this had increased the demands upon the coal produced in this country. A further claim on the output of coal in this country has been caused by the entry of America into the war. The American Army now fighting in France is a long way from its base, and the transport of coal from America to France to carry on the necessary railway traffic for the American Army is out of the question, and, consequently, the British coalfields are called upon to supply a very large quantity of coal monthly for our American allies. The Government are extremely anxious to keep in close touch with the neutral Governments, and one of the chief factors in retaining intercommunication with them and securing the return of commodities necessary to this country is to supply those neutral countries with coal. By supplying them with coal we receive in return not merely the necessary foodstuffs as well as the raw materials necessary for the prosecution of the war, but we also have the use of their shipping, which is of the utmost importance at the present time.

"The Coal Controller, on figures supplied to him from the various mining districts in Great Britain, is of the opinion that if unnecessary voluntary absenteeism were abolished, and if the mine workers, upon whom the nation depends at the present time for the life blood of its industries, were producing to their utmost capacity, the nation would be able to tide over its present difficulties. The Executive Committee of the Miners' Federation during the recent wages negotiations pledged themselves to do everything in their power to secure the largest possible output of coal from the mines. It is recognised that the first claim on the output of the coal mines will be for the navy, munition works and other essential industries, and in the event of a real shortage of coal there is a serious danger that the ordinary household consumer will be very short of coal during the coming winter, and in spite of any precautions that may be taken to share out fairly the coal by rationing there is a likelihood that the poorest of the people may suffer most. The Miners' Federation are exceedingly anxious that everything possible shall be done by the mining community to prevent, as far as possible, unnecessary suffering in the homes of the poor for lack of fuel. In spite of all the efforts which can be made by the British Government to supply France with coal, the rationing in France has already been reduced to about 1¼ tons per household per year, and this, in all probability, will have to be considerably reduced unless we can not only maintain, but substantially increase, the output of coal in this country. Italy is even in a worse position.

"There may, and undoubtedly does, exist in many of the districts a strong feeling with regard to recent increases in the price of coal, and the opinion may be widely held that coal-miners or middlemen are reaping considerable benefits from the present national crisis. This may or may not be true, but it ought not to be taken as a reason at the present time for the mine-workers not doing their utmost to maintain the output of coal.

"We are endeavouring to establish within the next few weeks Joint Committees at all the collieries to lessen as far as possible unnecessary absenteeism, and the work of those committees will not be confined merely to make inquiry as to why individual workmen are not attending regularly at the mines, but they will go fully into the question, when it arises, as to why loss of output takes place, whether it is through the fault of the workmen or the management. We appeal to all our members to assist us in carrying out loyally the pledge which the Executive Committee have given to the Government that so far as they were concerned everything possible would be done to maintain, and if possible to increase, the output of coal, and with this object in view we would urge every miner to work every day on which the colliery is open for work, if health and circumstances permit."

Since the settlement of the recent aircraft strike in the London district (see page 84 *ante*) there have been discussions between the parties with a view to a friendly arrangement which should remove all feeling of bitterness and lead to the harmonious working of the factory. As a result, both sides submitted the following suggested terms to the Minister of Munitions:

It is agreed that the terms of settlement *re* the dispute between the Alliance Aeroplane Company and their workpeople shall be as follows:—(1) Rock to be re-engaged. (2) The management to continue to recognise the Shop Stewards as hitherto, provided the Shop Stewards are elected by the workpeople in the shops and on the understanding that works' rules are conformed to. (3) For the purposes of negotiation the management to recognise a small committee not exceeding seven in number, consisting exclusively of Shop Stewards and elected by the Shop Stewards. (4) The ordinary procedure for a workman bringing any question before his foreman shall be allowed. In the event of the workpeople desiring to put any case before the management, it shall be done in the first instance with the foreman or manager of that department, and if no settlement is reached it shall be discussed between the standing Committee of Shop Stewards mentioned above and the management. If these discussions do not result in a settlement the whole matter at issue shall be referred either to the executives of the unions affected or to the London District Aircraft Committee on the one hand and on the other to the Engineering Employers' Federation.

The Minister of Munitions, in view of the agreement, and having the same object as the parties, concurs in the arrangement. As a natural result, the decision to make the factory a national factory will be cancelled.

On opening the British Scientific Products Exhibition at King's College, last Monday (we deal with the exhibition itself in a separate article in the present issue), Professor Gregory stated that since the advent of the war the spirit of distrust which formerly existed between scientific workers and manufacturers had been largely dispelled, and an alliance was being formed which should increase in strength. It had been popularly assumed that original scientific work was almost a prerogative of Germany, whereas most modern industries had originated with British science and invention. In scientific research and in initiative we had been the pioneers. Where we had been deficient was in the practical use of the results obtained, and in the application of our natural scientific genius to industrial problem. Thanks to Sir Herbert Jackson, professor of chemistry at King's College, there had been a reawakening of the glass industry, and we had secured a position which was strong enough to enable our manufacturers to meet all assaults upon it. The pure potash required for certain glasses was being obtained by a new electrolytic process, and we need never again go to Germany for it, nor for the glass itself. Our chemical manufacturers were meeting all demands for synthetic organic drugs, photographic chemicals, synthetic dyes, and associated products, as well as hundreds of similar substances of which Germany had had the monopoly.

Professor Gregory also said that the magneto industry had established itself in a sound position, and the German instrument had been displaced for good. Hard porcelain for electrical fittings and laboratory ware was now British made. We were producing all the tungsten required for special steels and metallic filament lamps, and could supply the world if necessary. British-made aluminium alloys were superior to any of the German pre-war products, and an equal success had been attained in other directions. He regretted that the Education Act did nothing for scientific and technical education. We were lamentably behind Germany and the United States in the number of students taking higher courses which fitted them for the leadership in industry. This was our great need.

Speaking at the annual meeting of the Consett Iron Company, held last Saturday, at Newcastle, Mr. Mark Fenwick said that more and more men continued to be taken for the army (they had lost 639 during the past year) with the result that the output of coal, steel and iron continued to diminish. Up to a month or so ago they were making a reasonable profit on coal, but now this was much decreased, and was still decreasing. The prices for coal were based on those of 1914, and although certain additions had been permitted, much had to be returned to the Coal Controller to meet war wages, and present figures did not cover the increased costs. The production of coal for the past year was very disappointing, showing a reduction of 7 per cent. on the previous year, and 28 per cent. on 1914. Coke-making had somewhat increased; their coke and by-product ovens continued to justify the expenditure upon them, and the directors were considering laying down another battery when circumstances permitted. The high prices for pit timber were largely responsible, taken in conjunction with wages, for the greatly increased cost of the collieries. The reserve for reconstruction was much as last year, but would need to be increased, which might be done by drawing on the undivided profits, now standing at 229,000*l*. Many thousands of pounds would also have to be spent on their railways, and they were setting aside 50,000*l*. out of the year's profits as a nucleus for that expenditure. The interest on investments showed an increase of 50,840*l*., and the total from that source was over a quarter of the amount to be distributed in dividends. Increased taxation was such that it was improbable they would be able to pay a higher dividend, and in view of the extra 1*s*. on the income-tax, it was possible it might have to be reduced.

The Minister of Pensions is making a special effort to secure for as many disabled officers and men invalided from the Services as possible employment of a kind that offers a reasonable prospect of permanency. It is recognised on all hands that these men deserve special consideration, and that, as far as practicable, they should be saved from the anxieties attendant on uncertain employment, particularly in view of the conditions that must inevitably ensue on demobilisation. He has, accordingly, invited the County Councils, Municipal Corporations, and Urban and Rural District Councils through their Central Associations, to assist him in this object by giving a preference to the discharged disabled officers and men for employment in their service. Local authorities have, in practically all cases undertaken to reinstate their former employees who have joined the Forces, but there must still be many vacancies for which discharged men would be suitable. For those pensioners who will not, at the moment, be able to take such employment, owing to their disablement, the Ministry of Pensions will provide technical or industrial training.

The Associations referred to have responded to the Minister's appeal, and have unanimously passed resolutions expressing themselves in favour of a preference being given to disabled officers and men for employment in the local public services, subject to the reinstatement

of former employees and the requirements of those services.

Mr. Hodge's scheme has the support of Mr. Hayes Fisher, the President of the Local Government Board, and of Mr. Roberts, the Minister of Labour, and an invitation is now being issued to each Local Authority and to the several local War Pensions Committees, urging each of them to give practical effect in their own localities to the resolutions of the Central Associations.

INCOME TAX AND DEPRECIATION.

A NEW "Statement" (the second this year) has been issued explaining the income-tax "allowances for wear and tear and obsolescence of plant and machinery, &c." It repeats the previous statement, with the addition of the new concessions in the Finance Act, 1918. The table of agreed rates is also repeated, and may be summarised thus:—3 per cent. on electric light and tramway cables and gas holders; 5 per cent. on machinery and plant, including engines, boilers, shafting, &c., in electric undertakings, flour mills, paper mills, printing works, saw mills, and railway wagons privately owned; 7 per cent. on tramcars and rolling stock; 7½ per cent. on machinery for flax spinning and linen weaving, flour milling, printing and binding, and general saw-mill machines; 10 per cent. on gas meters, cookers and fires, and on printers' type; 15 per cent. on steel manufacturers' plant, of which 5 per cent. is for normal wear and tear and 10 per cent. for war use; 20 per cent. on motor omnibuses and traction engines, tractors, motor cars and haulage plant owned by timber merchants and saw millers. Paper mills working day and night get 2½ per cent. extra to the 5 per cent. for day work only.

The foregoing are all on "written down" values. On ships the allowance is on the prime cost at the rate of 3 per cent. on sailing ships and 4 per cent. on steamers.

The list represents an agreement between the authorities and bodies of taxpayers in the industries mentioned. It will be noted that engineering and shipbuilding works, foundries, collieries, quarries, and mills and factories generally, including cotton and jute mills are not in the list. The only recent addition is steel manufacturing plant. The practical effects of the 1918 concessions are as follow:

1. A body of taxpayers in any industry may have their trade added to the list, and the amount of the allowance settled by the Board of Referees—a non-official body, including engineers, traders, bankers, accountants, &c.

2. Depreciation on idle plant is allowed if its idleness is attributable to the present war—directly or indirectly.

3. The net cost of replacing scrapped plant is allowed. This means that on a machine being scrapped or sold as obsolete, the difference is allowed between the first cost and the total depreciation allowances plus the scrap value. An example is given: A machine cost 1,000*l.*; depreciation has already been allowed to a total of 600*l.*, and it fetches 50*l.* when sold; then the 350*l.* will be allowed as a "trade expense in the year of replacement." Former legislation provided as much, and in practice it was allowed by some Commissioners and, apparently, refused by others. It may now be claimed in all cases.

4. Owners of mills, factories and similar buildings may put aside, free of income tax, one-sixth of the annual value to form a sinking fund to replace the building. The language of this explanation is curiously involved. "He is allowed every year absolutely tax-free a sum equal to one-sixth of the annual value" . . . &c. This means no more than that the owner has to find the one-sixth himself, and that if he applies it to replacing the worn-out building in which his business is carried on the State will not tax that one-sixth as if he had spent it on his own personal pleasures. The statement, as a whole, is far from lucid.

THE INSTITUTE OF METALS.—The autumn meeting of the Institute of Metals will be held in the rooms of the Chemical Society, Burlington House, Piccadilly, W.1. The meeting will commence at 7.45 p.m. on Tuesday, September 10, and 4 p.m. on the following day, concluding the same evening. It will embrace three Sessions. The following communications are expected to be submitted in the order given:—September 10 (evening session, 7.45 p.m. to 10 p.m.), 1. "The Effect of Progressive Cold-work upon the Tensile Properties of Pure Copper," by W. E. Alkins, student member (Manchester); 2. "The Resistance of Metals to Penetration under Impact, including a note on The Hardness of Solid Elements as a Periodic Function of their Atomic Weights," by Professor C. A. Edwards, D.Sc., member of council (Manchester). September 11 (afternoon session, 4 p.m. to 6 p.m.): 3. "Grain Growth in Metals," by Z. Jeffries, D.Sc., member (Cleveland, Ohio); 4. "Rapid Recrystallisation in Deformed Non-Ferrous Metals," by D. Hanson, M.Sc., member (Teddington); 5. "The Influence of Impurities on the Mechanical Properties of Admiralty Gunmetal," by F. Johnson, M.Sc., member (Birmingham); 6. "Rapid Method of Estimating Phosphorus in Bronzes," by T. E. Rooney, member (Teddington). September 11 (evening session, 8 p.m. to 10 p.m.): 7. "A Peculiar Case of Disintegration of a Copper-Aluminium Alloy," by R. Seligman, Ph.D., and P. Williams, members (London); 8. "Annealing Cold Rolled Aluminium Sheet by Abbreviated Exposures at Various Temperatures," by R. J. Anderson, B.Sc., Met. E., member (Cleveland, Ohio); 9. "Alloys of Copper and Zinc: an Investigation of some of their Mechanical Properties," by F. Johnson, M.Sc., member (Birmingham); 10. "Use of Liquid Fuel in the Foundry," by Captain A. E. Plant, member (on active service).

"COAL SAVING BY SCIENTIFIC CONTROL OF BOILER PLANTS."

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to the letter of your correspondent, "J.W.," in the issue of August 2, 1918, I have not given the rate of evaporation with regard to heating surface, although the figures could easily be worked out, as I have the complete data of each of the 250 plants. I do not, however, quite see what would be the particular value of such data, especially in view of the fact that with a subject of this description it is already difficult enough to present the more essential figures in a readable manner, but I should be very interested to have the further views of your correspondent. In reply to your correspondent, Mr. C. A. Rossetti (August 2, 1918), I will endeavour to answer the various points he raises.

Mr. Rossetti first of all objects to the statistical methods I have adopted of presenting the figures. It is, of course, not an easy matter to present the results of about eight years' continuous scientific investigations into the working of steam-boiler plants, and I wish it could have been possible to have given the complete separate figures of each of the 250 tests. Apart, however, from the question of paper shortage, the trouble is that such a vast and dreary mass of figures would not be read in these busy times, except by a few enthusiasts.

The alternative, therefore, is to "boil down" the figures, and present a summary in an as attractive a manner as possible consistent with reasonable accuracy. Perhaps I have not been very clear as to how the figures were averaged, but my only object was brevity, and I will now explain in a little more detail. The separate figures of each of the 250 tests were set down on large sheets of paper, and the total weights of coal and water used were added together. A true mathematical average was taken of the heating value of the fuel by laboriously multiplying up each of the 250 heating values by the separate weights of coal and dividing by the total weights of coal.

These are the essential figures on which the efficiency calculations are based. The lesser important figures, like temperatures, pressure and draught were obtained by simple addition of the figure of each of the 250 plants and division by 250, and the resulting figures are for all practical purposes the same as the true mathematical average. The resulting set of figures was then worked out in the ordinary way, as if they were the figures of one plant only, instead of the whole 250, and, in my opinion, give a very good average of the working conditions obtaining in all the plants. At any rate, if Mr. Rossetti can suggest a better method, I shall be very glad to know of it. It must be remembered also that I gave in further detail the efficiencies of all the plants in divisions of 5 per cent. efficiency at a time; thus, 62 of the plants (equal to 24·8 per cent.) were working between 55 per cent. to 60 per cent. efficiency, and so on. I am, therefore, at a loss to understand what is meant by the statement that I have given "no sound basis for judgment concerning . . . the extent of the improvement obtainable."

Secondly, I am afraid that Mr. Rossetti has not quite grasped the object of my article, which was simply to give the *facts* relating to the results at present being obtained in boiler plants in this country, so as to show what saving is possible by the adoption of more up-to-date methods.

It is common knowledge among scientific engineers that our boiler plants are not very efficient, but no one (so far as I know) has published much unprejudiced information as to the *amount* of the loss, and I am trying to lend a hand in filling this gap in our knowledge.

I should have thought it was obvious that when I state the average saving on all the plants of Great Britain, based on these 250 representative tests, is 4·35 per cent. efficiency, due to economisers and 0·51 per cent. efficiency, due to superheaters, this is no argument against the use of economisers and superheaters, but is simply a statement of fact showing that these appliances are not installed in the most efficient manner to obtain the best results possible. Also I have not given the lines along which improvements can be effected in boiler plants for the simple reason that this has nothing whatever to do with this particular article.

With regard to Mr. Rossetti's remarks on mechanical firing *versus* hand firing, I have an open mind on the subject, and I think I have had experience of practically every type of stoker on the market. I hope to deal very fully with this subject in a future article, but there is one point to which I must immediately take very strong exception.

Mr. Rossetti states "in most cases mechanical firing with an efficient self-cleaning furnace, is essential for the use of low-grade fuels, &c.," and infers that mechanical stokers make a saving as compared with hand firing by burning cheaper coal, even refuse. It would be much more accurate to say that one of the chief *defects* of mechanical stokers is, generally speaking, that they will not handle cheap coals efficiently, especially in boilers other than tubular, and that a great advantage of hand firing is that all kinds of quality of refuse coal can be burnt mixed up together or separately as may be desired. Also the cost of running a mechanical stoker under these conditions is considerably increased, which is not an inviting prospect when it is borne in mind that some types of mechanical stoker now in use on ordinary good-quality steam coals are costing, say, 25 per cent. of the initial cost per annum in up-keep alone, and are wasting enough steam under the bars to pay for the cost of a complete new stoker outfit every nine months or so.

The figure of 220 lb. of coal burnt per boiler per hour in 22 explosive factory plants is an obvious error, and should read 1075·0 lb., and I am much obliged to Mr. Rossetti for drawing my attention to it. In reply to your correspondent "Morgan" (August 9, 1918), I quite agree with most of what he writes concerning the necessity of standardisation, and the more active interest of the Government in steam generation. With regard to the question of the amount of coal that it is possible to burn economically on "Lancashire" boilers, I said "a good quality of washed coal, of, say, 13,000 b.t.u. per lb., and 7 per cent. to 8 per cent. ash, could easily be burnt economically at the rate of 35 lb. per sq. ft. (grate area) per hour." I can only assure your correspondent that I have done it myself many times, and it is quite practicable using mechanical draught, induced or forced.

This does not, of course, apply to average or poor quality of coals, and I pointed out that the figure with ordinary average quality of coal (say, 11,822 b.t.u. and 11·5 per cent. ash, as given as the average of the 250 test), was something like 25 lb. to 30 lb. Also, I can assure your correspondent from practical experience that quite a large number of boilers working to-day could have their output of steam doubled. A standard 30 by 8 "Lancashire" boiler, with a modern equipment of economisers on average coal can be made to evaporate 900 gals. to 1,000 gals. per hour with feed water at, say, 100 deg. F., going into the economiser, and, say, 300 deg. going into the boiler.

The rate of evaporation very largely depends on the quality of the coal used. Washed coal of 13,000 b.t.u., for example, would give 1,000 gals. to 1,200 gals. per hour. Many boiler plants are, however, running on less than 500 gals. per boiler per hour.

I do not quite understand the statement that 8 ft. diam. "Lancashire" boilers are too large to stoke efficiently. So long as the grate length is not more than, say, 5 ft. 6 in., the width has nothing to do with the efficiency of the firing, and my own experience is certainly that the possible efficiency of "Lancashire" boilers to be obtained by the adoption of scientific methods is the same, even up to 10 ft. diam.

I am very interested in the formula for calculating the installation of economisers, but can only repeat that economiser plants are, so far as my experience goes, installed in a very rule-of-thumb manner, which is borne out by the fact that the average saving in the country by economiser installations is nothing like the 15 per cent. to 25 per cent. claimed by economiser makers. I am, however, just now writing an article dealing with the performance of economisers in detail, and I hope to refer again to the letter of your correspondent.

With regard to the letter of your correspondent, "Mr. W. H. Casmey" (August 9, 1918), I am in agreement with his opinion that the general average grate length of the country on hand-fired boilers is far too long. Although the average is probably about 6 ft., hundreds of plants are working with 6 ft. 6 in., 7 ft., and even 7 ft. 6 in. Mr. Casmey's proposed figure of 4 ft. is, of course, a very drastic reduction indeed, but I certainly agree that at any rate, 5 ft. or 5 ft. 6 in., in most cases is ample, provided, of course, that the plant is otherwise arranged to suit these conditions.

Yours truly,
D. BROWNLIE.

August 12, 1918.

THE NEEDLE GUN.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of April 5, page 380, you publish a letter from Mr. C. E. Stromeyer, Manchester, concerning the needle-gun, the invention of which, Mr. Stromeyer ascribes to Mauser.

I have only just seen the issues of the paper referred to, consequently, it is quite possible that someone else has already written to you, or Mr. Stromeyer, to put him right. Mauser was not the inventor. The needle-gun was invented by Dreyse, of Dreyse and Collenbusch, Soemmerda, Thuringia.

Yours faithfully,
H. F. HENSHAW.

83-85, Queen Victoria-street, London, E.C.4.
August 6, 1918.

THE INDUSTRIES OF MOSCOW.—The textile branch of the Moscow industries is stated to be doing exceedingly well, having large turnovers; conditions are said to be much better than in Petrograd, partly owing to the fact that Moscow, by having coal mines in the district, and adequate supplies of peat and wood fuel, is far more independent of the Donetz coal. In contrast to the textile factories, the metal works are in a bad plight, owing to the cessation of the Bank credits. In the first quarter of the present year, 405 metal works had to close down, the number of hands employed exceeding 200,000.

RADIO-ACTIVE SUBSTANCES.—The Minister of Munitions has issued an Order dated August 13, prohibiting the purchase, sale or delivery of any radio-active substances, luminous bodies, or ores, without a permit, and providing that such returns of stocks, &c., shall be made as are from time to time prescribed. The Order applies to all radio-active substances, including actinium, radium, uranium, thorium and their disintegration products and compounds, luminous bodies in the preparation of which any radio-active substances is used, and ores from which any radio-active substance is obtainable, except uranium nitrate and radio-active substances which at the date of this Order form an integral part of any instrument, including instruments of precision or for timekeeping. Applications in reference to this Order should be addressed to the Controller of Optical Munitions, Ministry of Munitions, 117, Piccadilly, W.1.

TWIN-SCREW PASSENGER STEAMER "STAVANGERFJORD."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS, BIRKENHEAD.

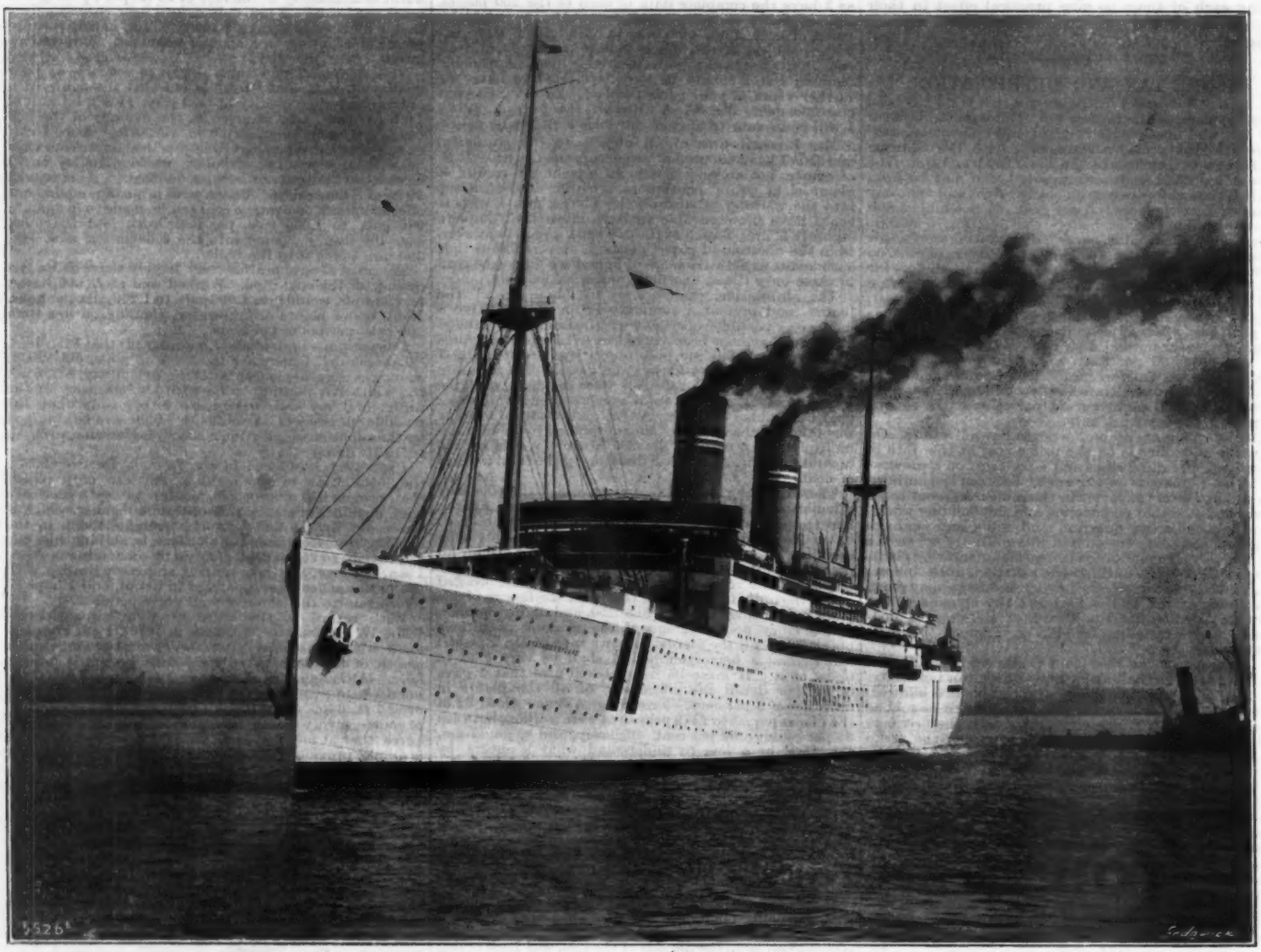


Fig. 13.

We illustrate in Figs. 1 to 12 on our two-page plate, in the view Fig. 13 on the page, and in Figs. 14 to 21 on pages 171 and 174, the first-class, twin-screw, passenger steamer Stavangerfjord, recently completed by Messrs. Cammell Laird and Co., Limited, at their Birkenhead yard, for Det Norske Amerikalinje, Christiania. The vessel is built of steel, under special survey to Lloyds 100 A1 class, and also to the Norske Veritas 1 A1. class. She also complies with the requirements of the International Conventions of 1914, and has passenger certificates from the British and Norwegian Boards of Trade. Her principal dimensions are the following:—Length between perpendiculars, 530 ft.; breadth moulded on the water line, 64 ft.; depth moulded to the shelter deck, 40 ft. 6 in.; her gross tonnage is 12,762 tons, and her speed about 17 knots. The vessel has a cruiser stern; she has also a cellular double bottom throughout, divided into numerous watertight compartments, and fore and aft peaks arranged as fresh water tanks. Large fresh water tanks are also provided alongside the shaft tunnels. A fresh water condenser is further provided for supplementing the fresh water supply if necessary.

The Stavangerfjord has accommodation for 88 first-class, 330 second-class, and 912 third-class passengers, in staterooms, as follows:—First-class passengers are accommodated in staterooms on the promenade deck, each containing two fixed berths and one sofa berth, also in two special rooms with adjoining private bathrooms built adjacent to the first-class lounge on the boat deck. The handsome first-class dining saloon on the promenade deck is arranged to seat 100 persons; it is fitted out in polished mahogany and upholstered in Morocco leather. The first-class smoking room on the promenade deck is neatly panelled and framed in burr walnut, having pictures of Norwegian scenery incorporated with the panelling. On the starboard side of the smoking room is the first-class ladies' room, panelled in inlaid satinwood, with satinwood piano, and suitably upholstered in silk tapestry. Directly aft of the smoking room and ladies' room is a verandah café. The first-class lounge on the boat deck is panelled in fumed oak. Figs. 14 to 17 on page 171 are views of the boat and promenade decks and of the first-class dining saloon and ladies' room.

The second-class passengers, for whom superior quarters are provided, as will be seen from the views Figs. 18 to 21 on page 174, are accommodated in staterooms on the bridge and shelter decks, containing two and four berths as shewn on the plan, Fig. 10. A large second-class dining saloon on the shelter deck is arranged to seat 160 persons, panelled and decorated in white enamel, and fitted with sofas and revolving chairs of light oak. The second-class smoking room on the bridge deck, extending over the full width of the house, is panelled in oak with alcoves arranged as shown on the plan, Fig. 9. A verandah café is fitted aft of this smoking room. The second-class lounge on the bridge deck is panelled and decorated in white enamel. Entering off this lounge is the second-class ladies' room on the port side, and the writing room on the starboard side. The ladies' room is panelled in light oak. The writing room is panelled in European walnut, with furniture to match.

Special attention has also been given to the third-class accommodation, which is of a superior description. Comfortable staterooms containing 2, 4 and 6 berths, as shewn on the plan, Fig. 11, are on the shelter, upper and main decks. Those on the main deck are portable. Two dining-rooms are on the upper deck, one fore and one aft; the one aft seats 266 persons, and the other 233 persons. They are panelled in pine, and provided with the necessary tables and revolving chairs. There are two third-class smoking rooms, one on the bridge deck aft and the other on the shelter deck forward, panelled and decorated in white enamel. There are also two music rooms for use of the third-class ladies, one aft and one forward on the shelter deck, panelled and enamelled white.

Two barbers' shops are provided, one on the bridge deck and the other on the shelter deck. Infectious hospitals are located aft on the bridge deck, and also male and female hospitals on the upper deck, with cabins for doctors and nurses alongside. First and second, also third-class galleys and bakeries are fitted on the upper deck amidships, and are supplied with the most modern appliances for cooking and baking. Two electric hoists run from the first-class galley for conveying food to the first-class dining saloon and officers' mess room. The captain and officers are accommodated in rooms on the boat deck, arranged complete with mess rooms, pantries, food lift, lavatories, etc. The engineers' quarters are in cabins on the upper deck, abreast the engine casing, and are complete with mess room and lavatories. The chief steward and purser, with their offices and enquiry bureau, are accommodated on the bridge deck. The firemen's quarters are on the upper deck, in eight berth rooms, together with a large lavatory for their use. Their quarters are divided off from the remainder of the accommodation, and so arranged that they have direct access to the stokeholds. The remainder of the crew are

TWIN-SCREW PASSENGER STEAMER "STAVANGERFJORD."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS, BIRKENHEAD.

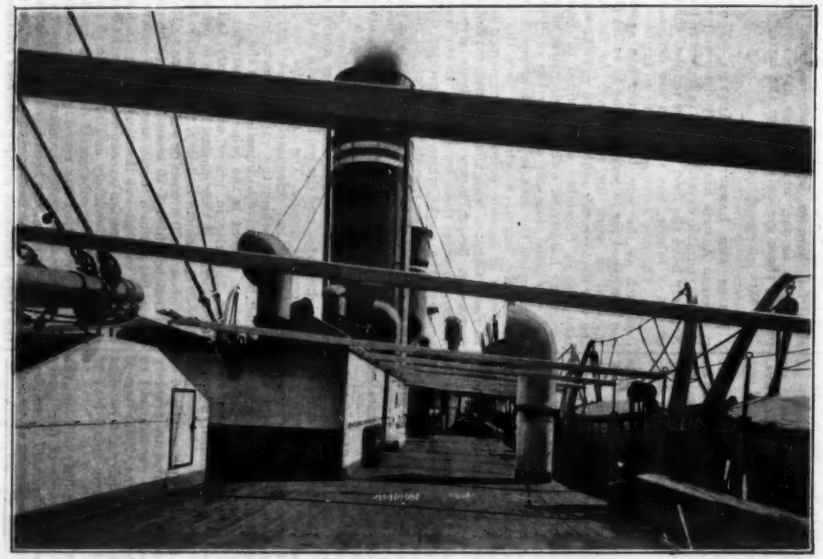


FIG. 14. BOAT DECK, LOOKING FORWARD.

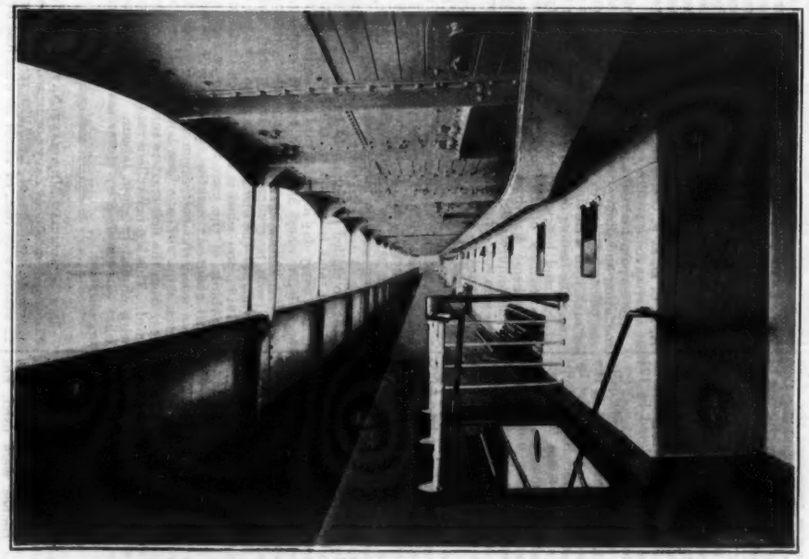


FIG. 15. PROMENADE DECK, LOOKING AFT.

FIG. 16. FIRST-CLASS DINING SALOON ON PROMENADE DECK.

FIG. 17. FIRST-CLASS LADIES' ROOM ON PROMENADE DECK.

in rooms on the shelter and upper decks as shown on the plans. Refrigerated store rooms are fitted on the main and lower deck forward, also two special cargo rooms.

The whole of the vessel is ventilated and warmed by the Thermotank System of ventilation. Electric lighting is provided throughout the ship, the installation consisting of three sets of direct coupled engines and dynamos of 75 k.w. each. There is an oil-driven auxiliary electrical installation in the engine casing on the boat deck, in accordance with the requirements of the International Convention.

Cargo is handled by means of derricks fitted to the masts, there being eight 3-ton derricks to the main mast, and four 3-ton and four 5-ton, also one 15-ton derrick to the foremast; further, four 3-ton derricks fitted to Samson posts at the fore end of the bridge. The derricks are built of steel tubes and fitted with strong blocks and gear. Sixteen steam winches are provided for operating the derricks, also two steam cranes fitted aft for working the baggage hatch. There are two steam winches for operating the lifeboats. Four steam capstans, two forward and two aft, are supplied for warping, those aft also taking leads from the relieving tackle. The vessel carries lifeboats of ample capacity for all persons on board, fitted under Welin davits. The wireless installation was put down by the Marconi Co. The steering gear is arranged in the cruiser stern and is on the Wilson-Pirrie system. Telemotor control is fitted from the bridge to the steering engine compartment, and also a control from the docking bridge aft.

(To be continued.)

Copper in Queensland.—It is hard to say where copper cannot be found in Queensland in more or less large deposits. But, of course, all the copper shows are not worked, and the bulk of the yearly output has been derived from a few favoured mines, which also contain gold and silver in considerable quantities. The celebrated Mount Morgan mine is a proof of this statement. But the extensive district of Cloncurry produces more than half the output of copper of the whole State. Several years ago it was confidently stated that the production of copper would be vastly increased, as would the supply of other valuable minerals in the North, by the construction of certain railways. These railways have been built, and, in his exhaustive report on the mining industry during 1915, the Under-Secretary for Mines lays stress upon the great value of railway communications between the distant mines and the eastern seaports. The vast copper mining district of Cloncurry has an area equal to that of the whole of Tasmania. The output from the field for 1915 was of the value of 758,965*l.* notwithstanding drought conditions and the war, which caused stringency in the labour market.

Cast-steel Chains.—We published in our last issue two papers on the manufacture of cast-steel chains, read before the American Society for Testing Materials. In connection with these two papers, we may state that Lloyd's Register of Shipping has now issued a memorandum regarding the manufacture of and testing of cast-steel chain cables, giving a history of this departure from the method of manufacture hitherto followed, and particulars concerning the testing of cast-steel chain cables. The memorandum states that the Committee have, after very careful consideration, come to the conclusion that, bearing in mind the requirements of the Anchors and Chain Cables Act, the following procedure will, as a tentative arrangement, provide a satisfactory method of testing cast-steel cables, whatever be the country of manufacture:—The breaking and tensile tests for cables of all sizes should be based upon 22·4 tons and 16 tons per square inch on the section of the links, these stresses being 40 per cent. in excess of those required by the Act for iron cables under 2¼ in. and over 1¼ in. It is essential that cast-steel chain cables shall be properly annealed after casting; this annealing should be the final operation of manufacture. The memorandum then details the conditions under which the tests are carried out.

The Late Professor Olaus Henrici.—Former students of the City Guilds Central Technical College will be grieved to learn of the death on August 10, of Professor Olaus Henrici, who was Professor of Mechanics and Mathematics at the above Institution from its opening in 1884 till his retirement in 1911. Professor Henrici had originally intended to pursue an engineering career, and his earlier studies had been conducted to this end. The attraction to mathematics came later, but his early training gave him special qualifications for teaching mathematics to engineers. He was a particularly clear lecturer, and the historical dissertations by which he introduced new subjects to his classes, arrested their interest by showing the practical considerations and difficulties which had necessitated the discovery of new methods of attack. To engineers generally, Professor Henrici's name was familiar, owing to his independent invention of the now universally adopted Bow-Henrici notation in graphic statics. He took a keen interest, moreover, in calculating machines, and was himself the inventor of a highly ingenious harmonic analyser, by which the co-efficients of a Fourier's series could be mechanically determined from a plotted curve of the function under investigation. Professor Henrici was a Fellow of the Royal Society and a past-president of the London Mathematical Society, and was the author of a number of papers on pure and applied mathematics. He was 78 years old at the time of his death.

HOG ISLAND SHIPYARD.

The following interesting notes respecting the shipyard* of the American International Shipbuilding Corporation at Hog Island, have been prepared by one of the surveyors of Lloyd's Registry of Shipping.

On September 13, 1917, the Shipping Board contracted with the American International Shipbuilding Corporation to build a shipyard, and build 50 ships of 7,500 tons d.w., the builders to receive no compensation for building the yard, but to receive 5 per cent. on the cost of the ships, and the ships were to be completed in 13½ months from the signing of the contract.

Hog Island is 900 acres in extent, and was virtually a swamp. On October 1, 1917, work was started at the island, and on October 13 a second contract was let by the Shipping Board to the American International Shipbuilding Corporation for 70 ships or 8,000 tons d.w., the 120 ships to be completed in 22 months from the signing of the original contract. Great forethought, judgment and daring have been shown throughout the whole scheme, as the yard is laid out to build 50 ships at one time, that is, there are 50 ways, 40 of which are wood and 10 concrete.

In the building of the yard 140,000 piles have been driven, 70 permanent bunkhouses to accommodate 4,000 men erected, 80 miles of railroad track laid, 300,000 yards of grading carried out, 4,000,000 yards of underwater dredging, and as no dumping is allowed in the River Delaware, 3 miles of dykes had to be built to form an impounding basin in which to dump the dredgings from hydraulic dredges through miles of piping; also 1½ miles of dykes built in the water and cribbed.

In addition to the yard itself, seven fitting-out piers have been built to enable vessels to 28 ft. draft to be moored alongside. Ten miles of planked roads have been laid, the 50 ways built, and 470 cranes, electrically operated, erected on towers for handling the material at the ways; 6,000 tons of steel were used in the construction of these towers alone.

A complete sewage system and a domestic water and filtration system, to use river water for domestic purposes, were installed, also, a high-pressure fire system, all equal to what would be required for a town of 50,000 inhabitants. The telephone system is also equal to a town of the same size with 80 trunk lines, 1,039 local lines in the yard, and an exchange with 31 operators who handle 125,000 calls per week.

The Corporation owns 15 railroad locomotives, 450 freight cars and 69 locomotive cranes for handling material in the yard; there are also 14 steam travelling cranes, that is, one on each side of each fitting-out basin. In the building of the ways, office building, warehouses, &c., 80,000,000 board ft. of timber were used, not including the piling previously referred to. There are two stock yards for receiving the fabricated material for the ships, one for the "A" ships, 1,000 ft. by 800 ft.; and one for the "B" ships, 1,000 ft. by 1,000 ft.; these stock yards are so arranged and laid out that all material is only handled twice, once on arriving and once on leaving by the travelling locomotive cranes for the ways. The laying out of these yards is most ingenious, and has been well thought out.

The two large plate and angle shops are built of steel and are each 630 ft. by 150 ft., with a mould loft 400 ft. by 60 ft. between them, and grouped round this section are all the necessary smith shops, plumbing, galvanising and all other shops which go to make up a modern shipyard.

At the present time there are 80 fabricating shops scattered all over the country, entirely engaged in making the various parts of the ships and sending them post haste to this tremendous erecting plant. In addition to all of this, the Corporation have organised on military lines a guard force of their own of 600 men; they have established a bank, a post office, four main fire stations and 5 complete power plants, that is, one for each ten ways. They have also a most complete and up-to-date hospital with all the latest appliances, X ray machines, &c, and a dental and eye section all under specially trained men.

The office force alone numbers 2,000, and, in addition, a special staff of inspectors are maintained in all the fabricating shops to ensure that nothing is shipped that will need correction or rejection on arrival at the island, and this has been the means of saving no end of time and money, as practically none of the fabricators has ever handled shipbuilding material before.

The yard was to be complete on July 15, and the whole undertaking, including the fitting out piers, basins, &c., by September 1, 1918—less than one year since the contract was signed—and this gigantic task has been performed largely through one of the severest winters ever known in this district, on many days with a temperature well below zero and weeks and weeks of snow and ice. Next to the Panama Canal in point of cost, it is the biggest thing ever done, and in point of view of the time in which it has been accomplished, a much bigger undertaking.

At the present time there are 27,500 men employed at the island, and when the whole of the ships are properly under way, about 35,000 men will be needed, and to complete the work in the scheduled time, 2,000 tons of fabricated material must be delivered daily and handled and erected; this alone will give some small idea of what the scheme involves.

The shipbuilding yard itself is splendidly laid out, the scheme adopted being to have 10 yards of five berths each, each yard having a superintendent and a complete set of foremen and officials with the necessary service and administration buildings at the head of the ways; then each 10 berths form a division with a divisional superintendent, and above him there is one superintendent for 20 ways (who also takes charge of the fitting out basins) and one superintendent for the other 30 ways. These two come directly under the general manager of ship construction, who, in turn, comes under the vice-president and general manager. At the head of the ways there is a straight street known as Front street, and then going back from that on a parallel line are Second, Third, Fourth, Fifth, and Railroad avenues between each division; there are also bisecting the yard A, B, C, D, E, F, G streets, and traffic police are posted at all cross roads to direct the traffic.

The corporation runs a large hotel with sleeping accommodation and dining-rooms, also one large cafeteria for the office staff, and in each service building at the head of each yard a cafeteria is established for the use of the men. The feeding of the huge staff of men is a big undertaking, and has to be handled with rapidity, as only three-quarters of an hour is allowed for each meal. The scheme has been most carefully thought out to the minutest details, and great credit is due to the men who conceived it, and are carrying it through.

The yard is 1½ miles long from way No. 1 to way No. 50, and 2½ miles long from the end of the fitting-out berths to way No. 50. Two template shops have been built, in which a complete set of engines and boilers are being erected with all necessary auxiliaries at the exact position, height, &c., in which they will be in the ship; all piping will be installed and sets made, and then everything will be fabricated for 50A and 70B ships, all ready to drop into place as each ship comes on.

As no skilled labour could be obtained, a school was started, and from 300 to 400 men pass through this school every day into the yard; a section of a ship has been built where men are taught riveting, caulking erecting, bolting up, pipe-fitting and any trade necessary. It is really marvellous to see how quickly and how well they learn. The first ship was to be launched on August 4, 1918; and when it is considered that not less than two-thirds of the men on her never saw a shipyard until about six months ago, this will be admitted to be a wonderful performance. By October 1, at least seven ships will have been launched—that is within one year from the first start to turn the swamp into a shipyard. This is a marvellous result to have been achieved with absolutely green labour. All this goes to show what can be done by clever management and careful organization.

* A short account of this shipyard, with illustrations, appeared in our issue of June 28 last, page 731.

The Norwegian Merchant Navy.—On July 1, the Norwegian merchant navy comprised 3,263 vessels of an aggregate tonnage of 1,926,220 tons. During June, 22 vessels were lost, of which 20 were lost by war calamities, and 22 vessels were likewise added, but the result was a loss in tonnage of 25,707 tons. Of the vessels lost, four steamers and 15 motor vessels were new and built in Norway. In Norway, as in neighbouring countries, barques and schooners have lately risen greatly in favour, whilst brigs have retrograded; at present, there are only two of the latter type left in Norway.

Prices and Labour in Austria.—The industrial position in Austria has recently deteriorated, owing to the unfavourable developments in regard to food supply. Not only have the food troubles reduced the individual output of labour, but the men are demanding higher wages. The men's demands have so far been conceded, inasmuch as the war department has agreed to pay the rise asked for in wages as far as such concerns are involved as work for the army. In the same way, the war department undertook to pay the wages of the men who in December were obliged to cease work in some war industries, owing to shortness of coal. The last concession does not only further swell the budget, but it makes the men in other branches also hold out for higher wages, which again has the undesirable sequence of causing prices for numerous commodities to rise. Coupled with this, the war expenditure keeps increasing. Several industrial products have also become dearer, amongst them being iron. In the iron industry, some of the works which have greater difficulties to contend against as regards the supply of coal and coke, amongst them the Prague Iron Works, and more especially the Alpine Montan Company, have for some time laboured under unfavourable conditions, although they to some extent, at least, have been able to sell at prices above the official quotations. The increase in the cost of production has now also caused other works to hold out for higher rates, and the result will be a material increase in prices all round. The authorities are being freely criticised for not adequately differentiating the conditions under which the various works labour, a fact which is conducive to injustice. As the Army Department at present is the principal customer of the iron works, the rise in prices will mostly fall upon this department. A very marked increase in price has taken place in the cement industry, the quotation having risen from about 8·30 kronen or 9·30 kronen to 13 kronen, in addition to which 5·10 kronen have to be paid for the paper bags which come more and more into use. Contrary to what was the case during the first years of the war, the Austrian cement works, like the German ones, have done better lately and been able to pay modest, some even fairly substantial dividends for 1917. The cost of production has certainly risen of late, yet the rise in prices is considered somewhat excessive. The cost of raw petroleum has been raised by 6 kronen, which is also ascribed to an increased cost of production; although the large petroleum refining concerns continue to work with very high profits they are demanding a rise in price of 2 kronen.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The steel-making industry has now got into full stride again, and there is every indication that the present intense activity will be maintained throughout the autumn months. Munitions are greatly in request, and large quantities of high tensile steel bars for shells are being rolled every day, while for the war programme and other work of national importance, a heavy tonnage of ship and boiler plates and structural material generally, helps to swell the enormous output. Without question, the munition factories, the shipbuilding yards and the general engineering works make heavy demands upon the steelmakers, who, despite difficult conditions, due mainly to the supply of raw material, endeavour to meet these demands in a most patriotic manner. Every ton of steel produced is rapidly absorbed on home account, and, consequently, only a very limited tonnage is available for export.

Malleable Iron Trade.—Notwithstanding the high prices now ruling for malleable iron, the works are as busily employed as at any time since the outbreak of war, the demand for bar iron apparently being on the increase. The orders which have been booked during the past few weeks certainly point towards something of the kind. Over the week an advance of 17*s.* 6*d.* per ton in the basis price of bar iron for home consumption has taken place, and "Crown" bars, net at works, are now quoted 14*l.* 15*s.* per ton. Another feature of note has been a very strict revision of the extra lists, and as the advances made apply to grades of material, as well as to sizes of sections, it may safely be said that a record figure for malleable iron has now been reached. The exceptionally heavy home requirements leave little for export.

Scotch Pig Iron.—The demand for pig-iron continues unabated, but all round the scarcity is such that producers have difficulty in making ends meet. More hematite seems to be available, and the entire output goes direct from the smelter to the steel works engaged on Government contracts. Unless better supplies of coal can be arranged for, there are troublous times ahead, when smelters will find it quite impossible to keep faith with their customers. Meanwhile, the entire production is being reserved for home use, very little being available for shipment abroad.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The passing of the August holidays has not brought any marked change in business. Here and there, as before the respite, departments are enjoying a brisk degree of production, but they are the exceptions. In the crucible steel line, the depression continues. The current demands for high-speed steel are not meagre, but there is a sufficient reserve of material in the country to enable them readily to be met. There is a particularly lively demand for acid steel. Steel for aircraft construction, too, is urgently sought. At last activities have been resumed in the iron foundries, the men having gone to work on Tuesday simultaneously with the opening of an inquiry by a Government representative, into the cause of the stoppage.

South Yorkshire Coal Trade.—A short holiday at the pits has not naturally improved the position in the coal trade. Every kind of fuel is now very strongly sought, and there is a general difficulty in obtaining the necessary supplies. For some time the output has been considerably on the short side, but there are now signs of an improvement in this respect. All classes of consumers, however, would do well to practice rigid economy. Quotations:—Best branch hand picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 26*s.* to 26*s.* 6*d.*; Derbyshire house coal, 22*s.* to 23*s.* 0*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

SPITZBERGEN COAL.—The reports from the Swedish coal fields at Spitzbergen are considered very encouraging. A first consignment of 600 tons to the Swedish State is shortly expected, and altogether, 6,000 tons should arrive in Sweden this summer, 2,000 tons having been broken at the time of the last news from Spitzbergen. The output should, from July, amount to 1,000 tons monthly, and for 1919-20, a production of 60,000 tons is reckoned upon. The quality of the coal at the Braganza coal fields is excellent, and its heating value is very satisfactory. The thickness of the main seam is 95 centimetres (37 in.), and the deposits are calculated to contain about 100,000,000 tons.

PRICES OF COAL AND IRON IN GERMANY.—The Rhenish-Westphalian Coal Syndicate, the Steel Union and leading iron works have been negotiating about a simultaneous rise in prices, to come into operation with the beginning of the next quarter. The rise for coal and coke is likely to average some 3 marks per ton. The prices for coal have not been raised since October 1, 1917, when they were advanced by 2,40 marks for coal, 3,60 marks for coke, and 2,50 marks for briquettes. The prices for iron have been left at the same level for some considerable time. There are no official maximum prices for coal and coke, but the works have agreed not to raise the prices without the sanction of the Prussian Minister for the Interior. The prices for iron are fixed by the Section for Raw Materials of the Prussian War Ministry.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Owing to holidays this month, less pig-iron is needed for the works, and thus at a time when distribution is hampered, needs are not so urgent as they have been, and in addition, several consumers are fortunately better placed as regards stocks, than for sometime past. Demand, however, for Cleveland pig iron, and especially foundry quality is still large, and in the case of foundry description exceeds available supply. Conditions vary at different works. Where furnaces have been on slack blast, owing to coke shortage, output of the lower qualities is disproportionately large; whilst at other works where make remains mainly of the standard quality, sufficient labour to load the iron is difficult to secure. Home sales of foundry iron have been on only a limited scale, but further considerable business in forge pig-iron has been put through on both early and forward account. Arrangements for the official allocation of shipments to Scotland, instead of despatching the iron by train, the object being to relieve the pressure on the railways, are understood to be proceeding satisfactorily. Exports to the Allies are reported going steadily forward. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all quoted 95*s.*; and No. 1 is 99*s.*; whilst for shipment to France and Italy, No. 3 and the lower qualities are 119*s.*; and No. 1 is 124*s.*

Hematite Iron.—The East Coast hematite branch presents few new features. By far the greater part of the output is absorbed by home consumers, who by the careful system of distribution, under strict official supervision, are receiving regular supplies, adequate to all essential needs. Exports to France and Italy are reported. As regards the latter, a few outstanding licences which remain in the hands of merchants, are being dealt with as heretofore, but no new licences are being issued, and as we foreshadowed last week, further shipments to Italy will have to be arranged direct through official channels. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to the Allies.

Manufactured Iron and Steel.—In the finished iron and steel industry, the manufacture of shipbuilding material is so well in hand that firms are able to devote much more time to the execution of other orders, and to some extent the heavy arrears of work are being made up. Next week most establishments will be closed for the annual holidays. Quotations all round are very strong, and an advance of 30*s.* is announced in iron ship rivets. To home customers, common iron bars are 14*l.* 15*s.*; best bars, 15*l.* 15*s.*; double best bars, 16*l.* 15*s.*; treble best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*—all net. Export prices are not fixed, but they may be given as, approximately, 40*s.* to 60*s.* above home quotations.

Ironstone Miners' Wages.—As regards the recent war wage granted by the Coal Controller to colliery workers, Sir Hugh Bell, Bart., this week informed the Cleveland ironstone miners' representatives that an arrangement had been made by the Ministry of Munitions for the extension of the wage to the ironstone miners and limestone workers. The war wage will take effect as from June 30 last, and back payments will be made to the men this month.

Coke.—Urgency of demand for coke is most pronounced, but supply shows no improvement, and it is with difficulty that the works are kept going. Medium blast-furnace coke is 33*s.* at the ovens; and low phosphorus quality, 35*s.* 6*d.* at the ovens. Pressing inquiry on behalf of neutrals meets with little or no success, and offers to pay 65*s.* f.o.b. Middlesbrough Dock for good foundry coke have to be refused.

THE STATE COPPER MINES IN FINLAND.—The Finnish State has, for a series of years, carried out work of a more or less preliminary nature at the Outokumyn copper mines, which are estimated to have a capacity of some 9,000,000 tons. At the end of the year 1914, the State had sunk 902,711 Finnish marks in the venture, and had acted in co-operation with a private firm, Hackman and Co. The State, not finding it expedient to undertake directly a continuous working of these valuable deposits, has now let the exploitation of the mines to an engineer, M. V. Hybinette, who represents a Finnish company, to be formed, with a capital of about 15,000,000 marks, the State and the above-mentioned firm having the option of taking shares for 250,000 marks each. The contract is for a period of 30 years, and the company is to pay a royalty of 30 per cent. on the net price, as long as that does not exceed 2,000 Finnish marks per ton; on any surplus price above this figure, a royalty of 50 per cent. has to be paid. The contract is to come in operation after the conclusion of peace between England, Germany and Russia. The above conditions are based upon a copper percentage of 4½ per cent., but only about one-third of the aggregate of ore is expected to contain that percentage of copper, the percentage of the remaining two-thirds of the ore being put at about 3½, and as far as such inferior ore is concerned, the royalty is reduced in proportion. At the end of two, or it may be three, years after the conclusion of peace, the royalty should amount to 1,000,000 Finnish marks each to the State and the firm of Hackman and Co., based upon an average price of about 1,300 Finnish marks per ton. The conditions of the agreement also provide for the company manufacturing 10,000 tons of sulphuric acid per annum.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—As had been anticipated, it is difficult to make up for the loss of output sustained through the miners taking three days' holidays in the Bank Holiday week. As usual on these occasions, they were by no means prompt in returning to work. This week, however, the attendance has been good, and, fortunately, stoppages are fewer than has been the case for some time past. It had been hoped, therefore, that the output would have been satisfactory, but it was estimated to-day that production this week again would not be more than 75 per cent. of the normal. Several factors may account for this, but there is noticeable an improvement as the week goes on, and the probabilities are that next week the position will be more satisfactory. There is, however, a great deal of leeway to make up, and heavy orders are now waiting to be executed while vessels are also delayed at the docks through lack of cargo. Strenuous efforts are being made to meet the situation both by the South Wales Coal and Coke Supplies Committee and by the Coal and Shipping Co-ordinating Committee, while both the owners and the men's leaders are concentrating their energies upon securing better outputs. One regrettable fact is that there are still 1,000 more men required from the coalfield for the Army in order to make up the quota from South Wales. The taking away of only 1,000 men perhaps should not make much difference, but as matters stand at present the industry cannot afford to lose one useful man.

Newport.—Practically all classes of Monmouthshire coals are very scarce, particularly the best qualities. All the stocks have been depleted, while even the small descriptions have been cleared off to a very material extent. The Risca Collieries which were idle prior to the holidays, the men refusing to work, owing to the discovery of a gob fire in an old seam on an adjacent colliery, have now been re-started, safeguards having been taken to obviate any danger arising from the fire. Coke and patent fuel are scarce, and the shortage of the former is re-acting prejudicially on the production of pig-iron. There is a particularly keen demand for inland requirements, and for the moment many of these remain unsatisfied.

Utilisation of Banked Small Coals.—With the view of seeing what can be done in the direction of counteracting the effects of the present shortage of coal, the South Wales and Monmouthshire Coal and Coke Supplies Committee have this week issued a circular to the collieries emphasising the fact that the shortage of coal was affecting not only factories, but also our Allies. The circular accompanied a form, in which collieries were requested to fill in particulars regarding the quantities and qualities of small coals at their disposal, which are now banked at the collieries. Included in the information asked for was a statement as to whether the available stores could be used for coking purposes either alone or with the addition of pure coking coal. A great deal of the banked small coals is, no doubt, unsuitable for this purpose, but it is likely that steps will now be taken to use up as much as possible of the small coal that may be banked at the collieries.

NORWEGIAN AIR TRAFFIC.—The Norwegian Air Traffic Company has just been formed with a capital of 3,300,000 kr., the programme comprising the selection of fixed routes and the transport of mails, goods and passengers.

TIN SALVAGE.—Manufacturers and packers who have accumulations of old tins, will find it worth their while to communicate with the Director-General of National Salvage, Caxton House, Tothill-street, before attempting to dispose of them. Tin box manufacturers throughout the country are also invited to put themselves in touch with the Director-General of National Salvage, who will be pleased to give advice, and, when possible, to bring buyers and sellers into touch with one another.

THE LATE MR. DANIEL MAKINSON FOX.—We regret to have to announce the death, which occurred at his residence, 9, Ormee-court, W., on the 13th inst., of Mr. Daniel Makinson Fox, M.Inst.C.E., F.R.G.S. Mr. Fox was in his eighty-ninth year. After serving a pupilage with Mr. Brunlees, he was engaged as assistant engineer on the Londonderry and Coleraine Railway for one and a half years. Mr. Fox then went to Spain, where he remained for two years, partly as resident engineer on the Mediterranean Line, having charge of works, and partly on surveys for the Great Northern of Spain and other lines. He was afterwards, for eighteen months, the resident engineer of the Gorsedda Slate Company's railway, North Wales. Mr. Fox went to Brazil in 1856, where he had charge of the surveys and other engineering duties for the Sao Paulo Railway, and then acted as the company's principal engineer. He became a member of the Institution of Civil Engineers in April, 1860, and read before that Institution, in March, 1870, a paper describing in detail the line and works of the Sao Paulo Railway, which railway at the time was the last in date of concession and of construction of the three Anglo-Brazilian systems, but was entitled to the first place from both the engineering and the commercial points of view. On two occasions, later, notably in 1886, when the working of railway steep inclines was before the Institution, he took part in the discussion, giving examples taken from service in the Brazilian Railway with which he was connected for so many years.

TWIN-SCREW PASSENGER STEAMER "STAVANGERFJORD."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS, BIRKENHEAD.

(*For Description, see Page* 170.)

FIG. 18. SECOND-CLASS DINING SALOON ON SHELTER DECK.

FIG. 19. SECOND-CLASS SMOKING ROOM ON BRIDGE DECK.

FIG. 20. SECOND-CLASS LADIES' SALOON ON BRIDGE DECK.

FIG. 21. SECOND-CLASS WRITING ROOM ON BRIDGE DECK.

TWIN-SCREW PASSENGER STEAMER "STAVANGERFJORD" FOR DET NORSKE AMERIKALINJE.

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

(*For Description, see Page* 170.)

Fig. 1.

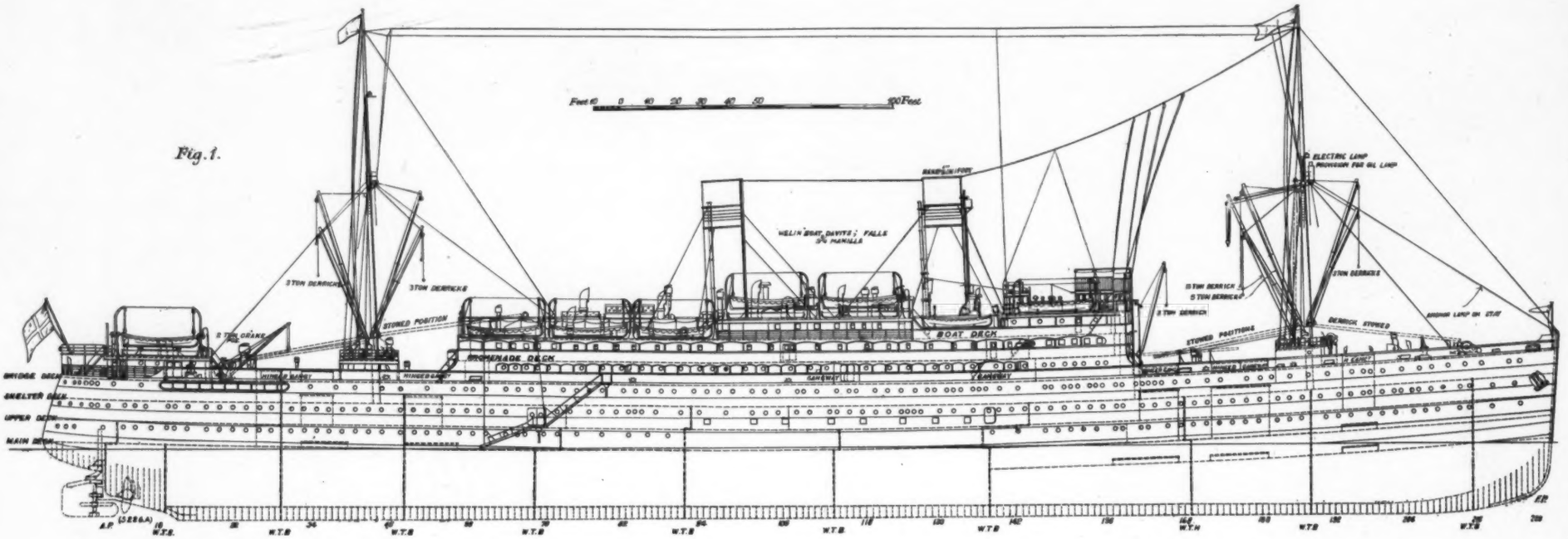


Fig. 2. MIDSHIP BOAT PLATFORM.

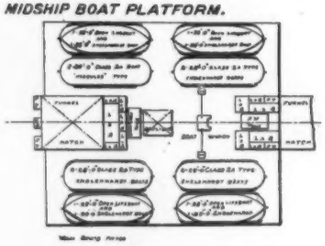


Fig. 3. BOAT DECK.

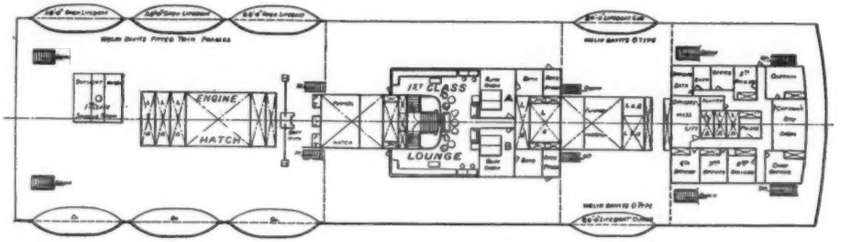
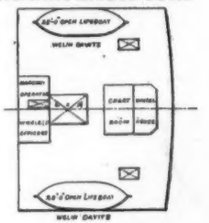


Fig. 4. NAVIGATING BRIDGE DECK.



AFTER WINCH PLATFORM.

Fig. 5. DOCKING BRIDGE.

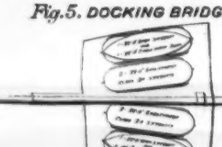


Fig. 6.

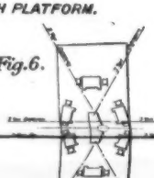


Fig. 7. PROMENADE DECK.

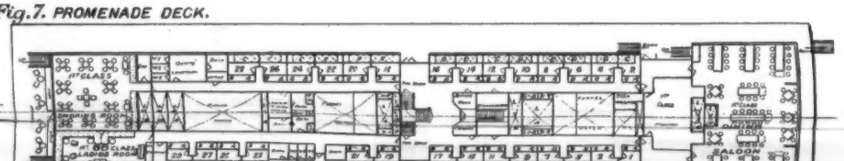


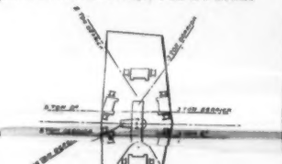
Fig. 8. FORWARD WINCH PLATFORM.

LETTERING OF BERTHS.

1ST CLASS:-
A = LOWER BERTH.
B = UPPER "
C = SOFA "

2ND CLASS:-
A AND C = LOWER BERTHS.
B " D = UPPER "

3RD CLASS:-
A.C.E.H. = LOWER BERTHS.
B.D.F.G. = UPPER "



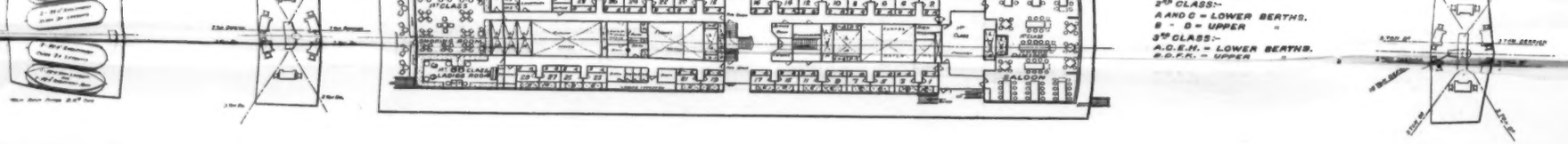


Fig.9. **BRIDGE DECK.**

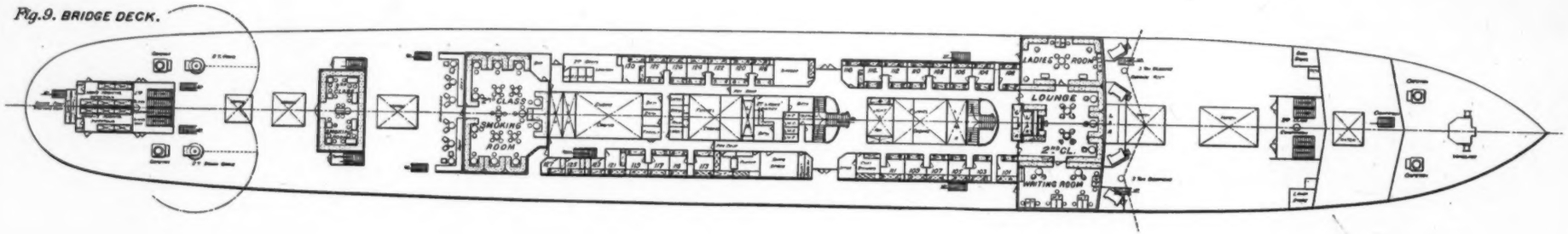


Fig.10. **SHELTER DECK.**

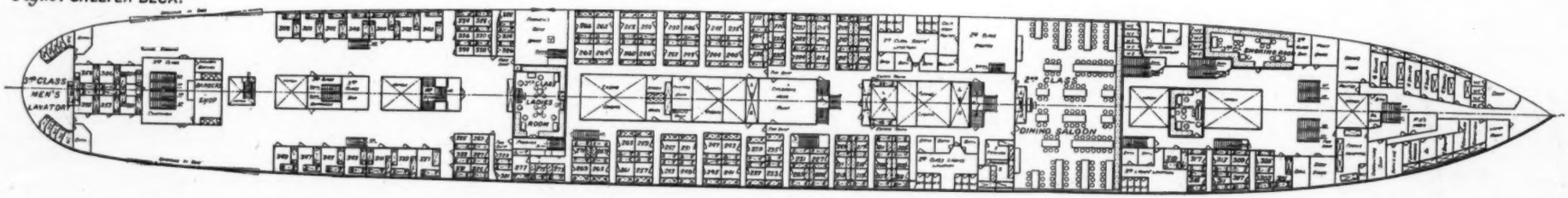


Fig.11. **UPPER DECK.**

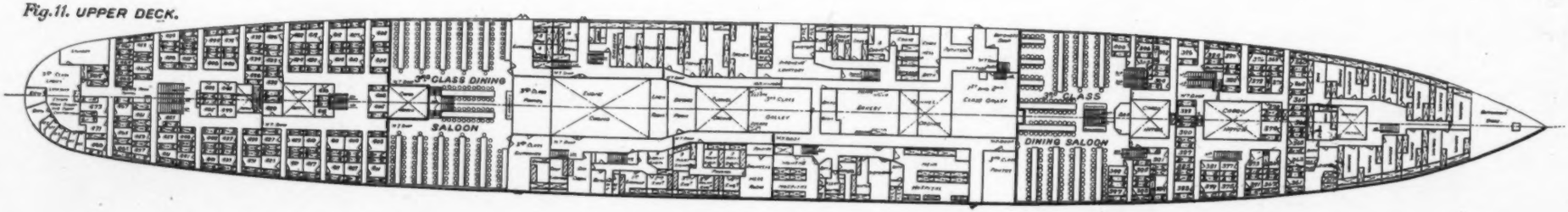
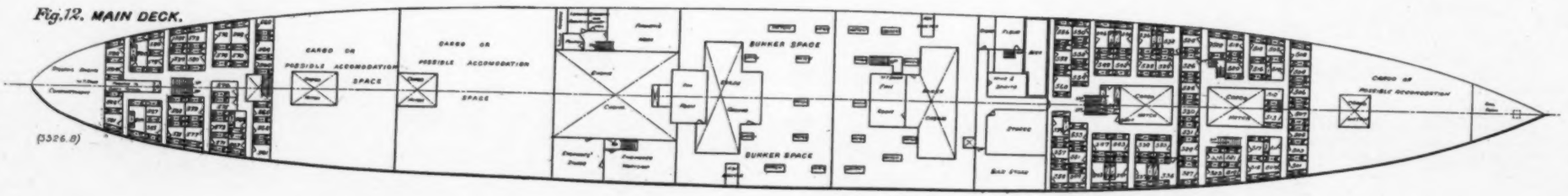


Fig.12. **MAIN DECK.**



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 8596 GERRARD.

CONTENTS.

	PAGE
A New Theory of the Steam Turbine (*Illus.*)	161
Aluminium (Bauxite) Deposits and the Production of Aluminium (*Illus.*)	163
Conveyor at the Wellpark Brewery, Glasgow (*Illus.*)	165
Industrial Notes	168
Income Tax and Depreciation	169
Coal Saving by Scientific Control of Boiler Plants	169
The Needle Gun	169
The Twin-Screw Passenger Steamer "Stavangerfjord" (*Illus.*)	170
Hog Island Shipyard	172
Notes from the North	173
Notes from South Yorkshire	173
Notes from Cleveland and the Northern Counties	173
Notes from the South-West	173
The Scarcity and Cost of Coal	175
Shipbuilding Prospects	176
British Scientific Products Exhibition	177
The National Physical Laboratory in 1917-18 (*Illus.*)	178
Literature	181
Books Received	182
Naval Patrol Boats (*Illus.*)	182
Connecting Subway Tunnel Tubes in Quicksand (*Illus.*)	183
Electric Arc Welding	185
Catalogues	186
ENGINEERING Patent Record (*Illus.*)	187

With a Two-Page Plate of the TWIN-SCREW PASSENGER STEAMER "STAVANGERFJORD" for DET NORSKE AMERIKALINJE.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 16, 1918.

THE SCARCITY AND COST OF COAL.

WE are rapidly drifting towards a crisis in the coal trade. Not only are we threatened with a coal famine in the coming winter, but the miners' programme, as outlined very definitely at the recent Southport conference, suggests that output will be so restricted, and cost of production so enhanced after the war, that it will be quite impossible for certain of our manufacturing industries, such as those of iron and steel, to compete successfully with their foreign rivals. It is useless even talking about "reconstruction" schemes if we are going to neglect this vital problem of coal supply. Without a fairly full output of coal at something like a reasonable price, British trade will perish. The subject is so important that we need offer no apology for dealing with it in some detail.

To begin with, the Executive of the Miners' Federation have, at last, issued an appeal to every man to work every day his colliery is open for work, if health and circumstances permit. In the manifesto it is stated that the Coal Controller, on figures supplied to him, is of the opinion that if unnecessary voluntary absenteeism were abolished and the mine workers did their best, the nation would be able to tide over its present difficulties. The executive, during the recent wages negotiations, pledged themselves to do everything in their power to secure the largest possible output of coal, and they appeal to the members to assist in carrying out the pledge. They are endeavouring to establish joint committees at all the collieries to lessen, as far as possible, unnecessary absenteeism. But what are the prospects of success in this direction?

Joint committees were set up for this same purpose about two years ago. At that time no less a miners' leader than Mr. S. Walsh, estimated that the loss of output due to avoidable absenteeism was equal to 26,000,000 tons of coal a year. In 1915, the output per man employed at the mines was 265 tons. In 1917, after two more years of war, and with a still more vital need for every man to do his best, the output was only 243 tons per worker. Whilst other industries are patriotically speeding up, the mining community is slacking down. It is a matter of supreme industrial and national consequence to follow the movement to its cause and to reveal the underlying forces to the public inspection. With all the facts before us, we can come to no other conclusion than this: Unless and until the Government changes its attitude towards the miners, these men will continue further to cut down their output, and at the same time to force up wages to such a pitch that coal prices will become prohibitive so far as our heavy steel and engineering trades are concerned.

The miners, as a whole, are a peculiarly susceptible class. A certain school of agitators have persistently poisoned the minds of the bulk of the colliers. The better judgment of these men has been warped, and a large number of them have adopted the view that they are justified in forcing wages up to extravagant figures, and in working very short hours. Absenteeism has become chronic. And the Government, instead of standing up for the interests of the nation, putting the facts to the men in plain terms, inducing the best of them to work to the best of their abilities, and penalising or punishing the worst of the time-losers (to say nothing of dealing with the mischief-making agitators), or, in other words, adopting a manly and straightforward policy, has pandered to the extremists among the miners, and has granted practically every demand they advance. The men have thus become persuaded that they have only to ask in order to have.

The result is that not only have wages been doubled since the war started, but output has been reduced instead of increased, and now the miners have decided to go in for another series of wage advances and allowances, coupled with a big reduction of their already short working hours. The new programme, formulated at Southport quite recently, provides for the nationalisation of the mines, the maintenance after the war of all the wage advances secured during the war—regardless of any fall there may be in food prices—for a still higher minimum wage, for several extra allowances, for pensions and paid holidays, for a five-day week with six days' pay, and for a six-hour day. Such a programme, if carried out, would mean ruin, so far as our manufacturing and shipping trades are concerned.

And the men intend it seriously, and will enforce it unless the Government takes the whole matter in hand fairly and firmly and fearlessly. To some extent the coalowners are to blame, for, although they have known full well of the shameless and false theories that have been spread in the mining villages during the last dozen or 15 years, they have never made a move to warn the miners against the agitators, or to counter or contradict the false doctrines. But the chief blame lies with the politicians and statesmen.

In the first place, the Government had not the courage to apply the Munitions Act to the miners. It had not the courage to suspend the Mines Eight Hours' Act, although the measure was carried with a special clause providing for its suspension in case of war or other emergency. It has not had the courage to tackle time-losing in this industry. It has not even had the courage to talk straight to the miners or their leaders. It has played throughout into the hands of the mischief-makers, and convinced the bulk of the men that they can defy the State with impunity. A new policy must be adopted.

The way the Government has so far handled the coal trade would be farcical, if it were not so serious to our national interests. In the early days of the war, under our haphazard recruiting methods, about a quarter of a million miners enlisted—all honour to those men—whilst millions of military age were permitted to remain in much less vital occupations. No class proved more patriotic than the miners, by the test of voluntary enlistment. No class have proved better soldiers. And among those remaining at home are some of the best workers and citizens in the country—men who would do anything for the good of the country. But these patriots get no help from the authorities. The whole policy of the Government tends to encourage and strengthen the extremists and mischief-makers, and in the struggle for directing the policy of the Miners' Federation the best men are swept off their feet.

The joint district committees that were set up two years ago to deal with this question of time-losing were defied by the shirkers. The Government refused to give the committees any power to fine or punish the absentees. In spite of that experience, it is now solemnly announced that more committees are to be established, but there is no hint of any powers being given. In the absence of power to deal with the time-losers, it is easy to forecast what will happen when the shirkers are openly declaring that they will not pay income-tax, and are deliberately keeping their earnings within the tax limit, which means that many of them are not working beyond 50 per cent. of their capacity. It may be said that the Government will neither permit the willing to work extra time by suspending the Eight Hours Act, nor yet insist upon any men working up to even the limited legal hours. Early in 1915, the Government surrendered its better judgment and allowed the Eight Hours Act to remain in force, because the executive of the Miners' Federation

objected to its suspension. The Government then sheltered itself behind a committee, and it has done little but appoint committees and controllers and advisors ever since.

We have lost count of the committees formed to deal with the coal trade, but can recall the following: First, there was a Coal Mining Organisation Committee formed to consider how best to maintain output in view of the heavy enlistments. That was foredoomed to failure. It contained too many members of the Miners' Executive, men pledged to oppose the best way of increasing output—namely, the suspension of the Eight Hours' Act. Then a Coal Exports Committee was appointed, and exports were cut down in order to relieve the situation in the home market created by reduced output. To-day our exports are at a rate of only one-third the pre-war level, and still there is an acute shortage for home requirements. Then the Government appointed a Coal Prices Committee, and a feeble attempt was made to keep prices down. But nothing was done to increase the individual production of the miners. Worse than nothing was done. Wage advance was given on top of advance, and war bonuses were granted, which had the effect of further reducing output by enabling the men to "make wages" with lessened efforts. The very least the Government should have done was to suspend the Eight Hours' Act, and lay it down that no man should have a bonus who failed to work full time. The Government played with this huge coal question, with the result that costs went up and production went down. With so many miners in the Army, the total output was bound to be affected, but our complaint is that the output per man left in the mines has been reduced when it ought to have been increased.

However, next a Coal Distribution Committee was set up to see that coal was delivered where it was most needed. We were told that so many million train miles would be saved. Remarkably enough, just a year later, and as if no such committee had ever been appointed, we were gravely told that a Coal Controller had been entrusted with the duty of arranging for the efficient distribution of coal. Following the Distribution Committee, which seemed at once to drop into a state of masterly inactivity, the joint committees, already alluded to, were created to deal with time-losing, but were given no powers, and their work proved derisory. The absentees laughed, and the agitators rubbed their hands in glee as they saw output go down. Next, we had the spectacle of delegates—mostly Socialists who were at the bottom of the trouble—called to London to hear long-winded and meaningless—certainly ineffective—speeches by Cabinet Ministers. The miners were praised for their splendid patriotism, and the delegates were asked to persuade the men to work a little better. The only response was another demand for more wages and a further drop in the individual output. The multitude of national and local committees continued to do nothing very effective, except harass coalowners and mine managers, and then Lord Milner was appointed to co-ordinate the work of all the committees and authorities. No good has been done. Still the Government is carrying on the same old game. There is no change of policy. There is no attempt to get to grips with essentials. Lord Milner's appointment was soon forgotten, and then Mr. Guy Calthrop was made Coal Controller. So long as nothing is done to permit the willing, or induce the others, among the miners to work a little harder in this time of crisis, so long as the Eight Hours' Act remains in force, so long as war bonuses are paid to men who will not work full time, so long as all manner of restrictions are imposed on managers, whilst none are imposed on the men or the agitators who prey on the industry, so long will the cost of coal production, partly through wages and partly through restricted output, mount higher and higher until all hope of industrial and commercial reconstruction after the war will vanish.

SHIPBUILDING PROSPECTS.

That the submarine menace was at one time exceedingly serious is indisputable, but, as Captain Mahon pointed out years ago, the *guerre de course* in which encounters with the enemy's fighting ships were avoided of set purpose, and his ruin sought by the destruction of his mercantile marine, has never in the whole course of naval history proved other than a disastrous failure. All precedent, therefore, was against the success of the reckless policy of the German High Command, which since the opening of the war has exhibited a singular incapacity to estimate any but the most obvious and superficial facts of the political and military situation. It soon realised, indeed, that a *guerre de course* governed by the previously-accepted rules as to dealings with non-combatants and neutrals would be relatively harmless; but quite failed to foresee into what straits a policy of unrestrained ferocity would ultimately lead it. The theory that a few raiders can starve out a great nation, suppress its commerce and ruin its industries has always been an attractive one, and had its counterpart here in the opening stages of the war, when many English papers, associated more particularly with materialistic views of economics, confidently proclaimed that Germany would be unable to withstand, for more than a few months at most, the economic strain to which she was subjected by the suppression of her imports and foreign trade generally. As a matter of fact, no great war has ever been brought to a successful conclusion in any other way than by hard fighting, and those who have sought an easier way out have uniformly been disappointed.

Undoubtedly, the callous disregard of common considerations of humanity has enabled Germany to cause a serious, if temporary, reduction in ocean-going merchant tonnage, but from now on a steady increase may be safely anticipated, as tonnage is at last being launched faster than the submarines are destroying it. It is true, unfortunately, that so far as British tonnage alone is concerned, the monthly sinkings are still somewhat in excess of new production. The net deficit has, however, fallen to 27,000 gross tons a month, and there is every hope that the monthly balance will soon be on the right side, and thence forward progressively increase.

It had been hoped that this condition of affairs would have been reached at an earlier date. Indeed, in one forecast it was suggested that some 4,000,000 tons might be turned out of British shipyards during the current year. Some of the conditions which have led to disappointment in this regard were set forth by Lord Pirrie last week. One cause is to be found in the very large amount of naval work in hand. In 1913, British yards launched 1,932,000 tons of merchant shipping and 271,000 tons of warships. For obvious reasons Lord Pirrie refrained from a direct statement as to the amount of naval tonnage now under construction, but he did state that the labour at present employed on naval craft is 25 per cent. more than that engaged in producing merchant tonnage. The naval output (in which is included not only ordinary war ships, but also numerous anti-submarine and salvage vessels) considerably exceeds anything hitherto achieved by this country.

The construction of the salvage craft above referred to has not only tended directly to restrict the production of new merchant tonnage by occupying berths which might otherwise have been utilised for cargo boats, but has indirectly caused a further reduction, since the repairs to the vessels salved occupy a relatively large number of specially skilled men. The net gain is, however, very substantial, as it takes much less steel and much less time to repair a damaged vessel than to build a new one. The salvage service is now exceptionally well organised, and under proper expert direction. The days when important salvage operations were deferred so that an Admiral might be present and take nominal charge of the proceedings, are now no more than an unhappy memory, and will not, it may be trusted, soon recur. Salved ships, moreover, are not kept waiting for long periods before they can enter the graving docks for repair. The service has been so organised that Lord Pirrie was able to state that only two ships were at that time awaiting entry. One other reason for the disappointing output of merchant tonnage was to be found, Lord Pirrie stated, in the fact that when he took up his present official position, he discovered that many yards were engaged on work of a mixed character, naval and cargo boats being under construction side by side. Before the war, it was, of course, a recognised principle that such a state of affairs was conducive neither to economy nor to output. One of the first steps taken by Lord Pirrie was accordingly to arrange for a division of the naval and mercantile work between different yards, and two-thirds of the yards at present employed on cargo boats are now doing no other work, and as the naval construction in progress in the remaining third is cleared off, it will be replaced by merchant tonnage, and so far as is practicable, each yard will, moreover, be confined to one type of ship.

Another reason given for the disappointment of our expectations as to output was the high quality of much of the merchant tonnage now building. Tankers and refrigerator vessels require some 50 per cent. more time to construct than do tramp steamers. The demand for the classes of boat in question is, however, imperative, and it is in all ways preferable to have them constructed here, where special experience is available, and to allow America to concentrate on the "fabricated" type of ship, for which, thanks to her bridge yards, the conditions are peculiarly favourable. These fabricated vessels have embodied in them not a single bent plate or curved frame. Not a component goes to the fire and the vessels can accordingly be assembled with a minimum of skilled labour. As models of these vessels have given excellent results in tank experiments, there would seem a prospect of the type being permanently established for the ocean tramp, and it is accordingly highly important that it should be also built at home here in Britain, where it originated.

Apparently it is on this ground that Lord Pirrie bases his defence of the National yards, since he claims that after the war the private yards will be fully engaged on making good the losses in the higher class of steamers. At the same time, he has frankly stated that, in his experience, a "Government managed concern was a badly-managed concern," so that the policy has, apparently, been accepted as a *pis aller*. It is, however, most unlikely, and we think most undesirable that the whole of our privately-controlled ship yards should be confined to the production of the higher class of tonnage. According to Kipling, the "liner she's a lady," but as he shrewdly points out, our mercantile position is, in the ultimate, dependent on our tramp tonnage.

According to Sir L. C. Money, the total British ocean-going steam tonnage was 18,500,000 at the outbreak of the war, and is now 15,000 000 tons gross. The net loss has, therefore amounted to 16 per cent. The German losses, including the ships seized by America, have, we believe, been over 1,500,000 tons on an original aggregate of about 4,340,000 tons. So that, subject to a correction for additions made during the past four years, the loss has been nearly 35 per cent., which is thus relatively more than double that of our own.

Indeed, were it not for the services we have to render to our Allies, even our reduced figures would be ample for all our actual needs. The burden on it is, however, steadily increasing, and must be met as quickly as possible by new construction. The introduction of the ferro-concrete ship will, no doubt, help. This system of construction has the advantage, Lord Pirrie says, of saving steel, saving plant and economising skilled labour, much of the work being such as can well be done by women. As the same moulds can be used over and over again, rapid repetition work should be possible. Some 56 of these concrete vessels are, it appears, now under construction, and others are to follow. In view of the high weight of the hull, however, which reduces the carrying capacity, Lord Pirrie seems doubtful whether the type will prove permanently popular. Of course, the fact that no riveters are required is, in present conditions, highly advantageous. The deficiency of these is, however, now in course of being made good, as, in one case at any rate, the Union has agreed that where it cannot supply the demand, holders-up may be permitted to act as riveters, subject, of course, to details being settled locally. The situation in this regard could, no doubt, be greatly eased by a more extended adoption of the pneumatic riveter, which is very little used in our yards, probably in the main, owing to the difficulty which is commonly experienced in introducing novel methods and appliances into British works and factories.

The charge that they resist improvements of this kind is often repudiate by the men's representatives and, apparently, in good faith. Inquiry, however, often shows that consent to the new arrangements is contingent on the whole of the benefit being secured by the workman Piece rates it is contended shall not be cut, although it is in some cases possible, with better appliances, to treble or quadruple the output, without additional labour or stress on the workman. On the other hand, the employer too often takes up the position that, as he has to assume all the risk attached to a new venture, he is entitled to the whole of the gain. From the logical standpoint this attitude may be indefensible, but logic pure and simple serves but as an indifferent guide to the conduct of human affairs, and we believe that a greater readiness to share with the workman the immediate gains attaching to new methods and appliances, would have often proved much more profitable than the policy too commonly pursued in the past.

Whatever the reason, whether it is to be found in the mutual attitude of masters and men above set out, it is, unfortunately, the case that the pneumatic riveter has made little headway in our yards. Returns from 70 of the leading yards in the country, show that the 10 best equipped have in use only 1½ riveting hammers per berth, instead of 20, which would be about the proper provision, were pneumatic riveting adequately applied. In 22 important yards, having 77 berths, there is, we learn, no pneumatic plant whatever.

The loss involved in this adherence to old methods is well shown by comparative figures obtained in a leading East Coast yard, where the best day's work with the pneumatic hammer was 700 $\frac{7}{8}$-in. rivets, and for hand work, under identical conditions, 430. These, as stated, are maximum figures, average figures being 510 rivets per day with the pneumatic hammer, and 264 with hand riveting. The above returns represent a general average, but the figures vary, of course, with the position of the work. Thus, the average day's work of a squad would vary about as follows: On the shell, with $\frac{7}{8}$-in. rivets, hand riveting, 260 to 360 rivets; with pneumatic riveting, 500 to 550; on the deck, with $\frac{5}{8}$-in. rivets, hand riveting, 450; pneumatic, 700; on deck, with $\frac{3}{4}$-in. and $\frac{7}{8}$-in. rivets, hand riveting, 350; pneumatic, 550. An additional advantage of pneumatic riveting is that the size of the squad can be reduced 50 per cent. This has proved of particular value in the States, where skilled men have commonly been fewer than the demand, and this condition has now become endemic here.

BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

THE British Scientific Products Exhibition was formally opened at King's College, on Wednesday afternoon, August 14, and is to remain open from noon to 8 p.m. every week day, till September 7. The King is the Patron; the opening ceremony was performed by Lord Sydenham, as President of the British Science Guild, and to this Guild, and particularly to Professor R. A. Gregory, the chairman of the Exhibition Organising Committee, is due the credit for the initiation and development of the undertaking. The British Science Guild had the sympathy and assistance of a large number of the leading scientists, scientific societies and institutions, universities and technical colleges and of official and municipal authorities; but whether their assistance went much beyond sympathy, and was of much utility to the organising committee and to its secretary, Mr. F. S. Spiers (secretary of the Faraday Society), 82, Victoria-street, Westminster, in the heavy difficulties of their task, we do not know. It is, however, far more important to find that the supporters of the idea largely come also from the ranks of the manufacturers. The exhibition is not in any sense a trade fair, at which purchaser and manufacturer meet. It is intended rather to enlighten the public as to our scientific and industrial strength and adaptability, as well as to stimulate confidence in our national capacity to meet, not only the needs of the present, but also the demands of the future. The chief purpose is to make clear the value of applying the results of scientific research to the arts and industries, and, further, to display to the public how much has successfully been achieved in this regard since the advent of the war, which in many directions revealed an appalling dependence of this country on foreign produce and instruments. The exhibits testify to the equally astounding progress already accomplished. No exhibition arranged during the turmoils of a world's war could be fully representative, of course. National considerations ruled out many scientific products. Yet the exhibition is very well stocked, far better, indeed, than it might appear at the first glance at the crowded rooms and passages, and the official aeronautical exhibits, of which the catalogue makes no mention, in particular will greatly interest the visitor.

The members of the organising committee did not deceive themselves as to the difficulties of their task. They had little choice as to locality, and when King's College had granted them shelter, and arrangements had been made with some manufacturers, applications poured in for more space than was available. We need not comment upon the general difficulties of delay, of transport and of getting anything done at present. Nobody, of course, now judges an exhibition from the show point of view. Visitors come to learn, and the instructive and broadly educational object of the exhibition was of primary importance to the organisers. So far as the general public is concerned, however, most exhibitions are only moderately successful in this respect. It is generally difficult to obtain information at exhibitions; frequently the exhibits are put in charge of some clerk who knows little about technical detail, and is anxious to say less, lest he betray professional secrets. At present, competent men to answer inquiries can be spared less than ever. To meet this difficulty, the committee have made arrangements that college students should explain where representatives of the firms cannot attend; these guides are obliging and very ready to impart information, provided they have received any. It does not facilitate their task that in some cases the articles had to be displayed in big glass cases, which cannot be opened. Whether, for instance, the chemical glass ware is as superior as is claimed, must partly be taken on trust. The associations of various cognate firms exhibit their products together, without any distinctive marks as to their origin, and they would have preferred, quite as much as the organisers, that the visitor could examine the perfection of a ground-joint and of a calibration, if that could have been arranged for. Occasionally the inquirer is rather puzzled by a dim recollection that an article which, he is now informed, was not manufactured in the country at all before the war, was formerly offered at a special price because of superior British make. The claims for novelty of manufacture are fully justified, of course. But it is not from that point of view only that the exhibition commands attention. What has been achieved is the result of scientific method and of co-operation. Scientific progress is necessarily slow, and a change in the mental attitude towards research can only be brought about by persistent effort and education. These points were emphasised in the remarks which were made by Professor A. R. Gregory and by Mr. L. Gaster, who presided, as chairman of the Circle of Scientific and Technical Journalists of the Institute of Journalists, during the informal opening of the exhibition on Monday last. Neither in elementary education, which does not touch science, however, nor in its secondary education, is this country behind others; when we consider technical colleges, however, the number of students—5,000 full-time day students against 40,000 in the United States and 17,000 in Germany—though taken at a younger age than abroad, moreover, cannot be compared to those of the countries just named. These points were further accentuated by Lord Sydenham, who regretted that the new Education Act did nothing for secondary and higher education.

More than 250 firms have sent exhibits, which are grouped in fourteen sections Some firms appear in several sections, of course, others are not especially mentioned in the catalogue at all, because they only participate in the group exhibits of manufacturers' associations. The exhibitors are arranged in alphabetical order, the only fair arrangement possible, but not the most convenient for a brief review of the exhibits. The catalogue opens with a number of very instructive articles on the recent developments of the various branches, compiled by experts; but these branches do not coincide with the sections. We should also mention the lectures and demonstrations given in connection with the exhibition. Sir William Tilden has discoursed on "Recent Progress in Industrial Chemistry," and Lieut. L. H. Parker, R.E., and others from the Munitions Inventions Department have demonstrated "The Oxidation of Ammonia." We have described this Ostwald process; the catalyst used consists of two layers of fine platinum gauze, placed, the one close above the other and heated by the electric current. We begin our notice with section I., chemical products and processes.

Chemical Products and Processes.—Three main divisions of industrial chemistry may be distinguished: (i) Heavy chemicals (acids, alkalis, ammonia, &c.); (ii) fine chemicals (including coal-tar products, dyes, drugs and explosives); (iii) application to arts and manufacture (metallurgy, glass, pottery, bricks, rubber, &c.). When the war broke out, this country held its predominant position in class (i); but that position was being rivalled, and in the other classes the country had long before lost any lead it could once claim, also, in particular, in chemical glass and porcelain—indispensable to research. Thus, the position was serious, all the more so because chemistry is the one of the parents of all manufactures which cannot be scientific unless based on a knowledge of what we are dealing with. As regards class (ii), there were ample stores of the raw material, coal-tar, but a deplorable deficiency in "intermediate products"—the products prepared from the benzene, toluene, naphthalene, phenol, which, though pure, are "crude" products in a sense—forming the raw materials for the manufacture of dyes and fine chemicals. There are now, Dr. J. C. Cain states, 22 dye works in the country, although the needs of munitions have severely handicapped all other chemical effort. Vat dyes are made by three more firms, and in the cheaper sulphate and azo-dyes, the demands can be met, but in basic and other dyes much remains to be done; what Dr. Cain wants is directors who direct, and not figure-heads. In the drugs and the fine chemical industry, good progress has also been made, according to Mr. C. A. Hill, president of the British Pharmaceutical Conference, but he deems Government assistance absolutely essential at the conclusion of hostilities. The supply of drug-plants should not fail. The artificial fertiliser industry was started by Sir John Lawes, in 1843; it declined somewhat of late, according to Dr. E. J. Russell, of Rothamsted, and this country supplied less than a tenth of the total annual production of superphosphates before the war. The basic Bessemer slag, of which 286,000,000 tons were utilized as fertiliser before the war, is now partly being replaced by the basic open-hearth slag, which is less rich in phosphate, and hence less valuable weight by weight, but not inferior otherwise. Of the ammonium sulphate produced in the country, 238,000 tons were utilised on the fields in 1917. Nitrogenous waste and offal are no longer disregarded as fertilisers. Potash fertilisers used to come altogether from Germany, but as potash is mainly wanted for sugar-beetroot and for sandy and moorland farming, that material was not indispensable for this country, which could fairly rely on its farmyard manure; potatoes and flax also require potash, however, some 22,000 tons per year. As to the utilisation of new sources of potash, nothing is to be learnt at the exhibition.

We will attempt to group the exhibits, which are dispersed over a number of rooms, though we can hardly hope for success in that endeavour in view of all the overlapping branches of manufacture. Acids and alkalis are represented by Messrs. Brunner, Mond and Co., who show ammonium nitrate produced by various methods: from synthetic nitric acid; from imported calcium nitrate and ammonium carbonate; from the same home-made products (obtained from the waste liquor of the ammonia-soda process and Chile nitre); and from nitre and ammonium sulphate. Their crude trinitro-toluene may be washed cold with alcohol, or crystallised from hot alcohol under vacuum, which gives the purer

product; synthetic phenol is also shown. The Castner-Kellner Company specialises in intermediate dye products, monochloracetic acid, phenylglycin, chlorbenzenes, crystalline or liquid substances; further, in liquid chlorine and hydrogen (the former in cast-iron cylinders with screwed-in stoppers) from the electrolysis of brine, tin tetrachloride (from the elements, for silk dyeing), sulphur chloride (for rubber vulcanisation, &c.). Messrs. J. Crosfield and Sons, of Warrington, exhibit caustic soda (perfectly white sticks or granulated), water glass (alkaline, in greenish-yellow lumps or neutral, resembling bluish ice, both for soap making), Portland cement, glycerin. The United Alkali Company, of Liverpool, supply a very high-grade 65 per cent. oleum sulphuryl and thyonil chlorides (for dyes); chlorsulphuric acid (wanted in the saccharine manufacture and also for producing vicious brownish smoke screens), phosgene $COCl_2$ (a very reactive and offensive liquid, so called because originally made by exposing chlorine and carbon dioxide to light); ethyl, formate (a solvent and for improving alcoholic beverages), perchlorates, and various compounds. Messrs. O. Güttmann and Sons exhibit cellular materials of earthenware or ironac for filling acid-absorption towers; the cells are of various shapes, diamond with blunt edges and corrugated on one or on both sides, twisted blades (Goodwin spirals), or simply stacked rings or grainy (Goodwin's diabolo filling). The Nitrogen Products Company, which is connected with the Alby Carbide Company, of Hepburn-on-Tyne, makes nitric acid by the Ostwald process, and calcium cyanamide (nitrolim) utilised as fertiliser or converted into dicyandiamide; their pitch serves as raw product for electrodes and is also retorted to produce light oils and fuel oils. The cylindrical electrodes of amorphorus carbon are of imposing dimensions, up to 20 in. in diameter, 6½ ft. high. They are fitted with screwed recesses for jointing, the electrode itself having a screw thread. Prismatic square electrodes of similar dimensions are also on view. Dr. F. Mollwo Perkin, the consulting chemist to the company, further exhibits the original mauve and a piece of the mauve silk dress, presented by his late father, Sir William Perkin, to the Queen Victoria.

The carbonate of potassium and other potassium salts, and the cyanides and ferrocyanides of the British Cyanide Company, of Oldbury, Birmingham, are all made from potash materials of this country. The ammonia and tar products of the Brotherton Company, of Leeds, lead over into the dye branch; the works make the finished dye, starting from the tar; their metachrome vat colours are described as fast to light, milling and potting (boiling for 48 hours), whilst their sodium hydrosulphite and formasol (consisting of this sulphite and formaldehyde) replace as stripping (decolouring) agents, the German rongalite, hydralite, &c. The Gas Light and Coke Company, of Beckton, have a very impressive show of coal-tar products, including pyridine, fuel oils for shell-furnaces, navy-oil, aspirin, phenaceton, ferrocyanides and bronze blues in lumps, powders and pastes—in addition to the sulphuric and nitric acids, made by chamber and contact processes. Messrs. R. Graesser, of Ruabon, show their acrosyl (a substitute for lysol), cresols, phenol, picric acid, aurini (a dye), allantoin (drug), &c.

Prominent among the exhibitors of dyes are Messrs. Levinstein, of Manchester, who were able to acquire German dye works in the North, together with other firms; the Solway Dyes Company, of Carlisle, whose works for vat dyes (blue, yellow, red, green) of the indanthrene type were only started in 1914, and the London Dye Manufacturing Company, of Stratford (aniline colours and intermediate products). Most of these dyes are claimed to be fast in every respect, but the bright shades do not look very successful so far. The Beaverhill Colour Company, of Edinburgh, supplies artists' colours made from Canadian ores; the Nottingham Chamber of Commerce makes a speciality of stainless fast aniline blacks for cotton and Lisle hose, and of puers for leather manufacture, made from pancreol.

In the drug and pure chemical industry, which often goes together with dyes, we notice Messrs. Boots, of Nottingham (varied antiseptics, acriflavine, aspirin, acetanilide, chloramine), hyoxyamine and other alkaloids, and saccharin; their sweetening agent is orthobenzoyl sulphurimide, or the soluble sodium compound of this body, and is closely allied chemically to halazone, a disinfectant powder; The British Drug Houses (80 preparations of medicinal chemistry, microscopic reagents and dyes and stains for blood, &c., and pure chemicals distinguished as A.R., analytical reagents); The British Pharmacy Company (paraffin, resorcin, aniline dyes); The British Resorcin Company, and particularly Messrs. Burroughs, Wellcome and Co., and The Wellcome Chemical Research Laboratories, long famous for their superior drugs, tabloids, and for their enterprise in research. Notable are their ipecacuanha and hop preparations, and their kharsivan and neopharsivan (identical with salvarsan and neosalvarsan), the first British products of this type, made since 1914 from soamin, on which the laboratories had previously been working. The Chemical Research Laboratory of St. Andrews' University, also noteworthy in the same field, took up novocain, the study of sugars, and the recovery of acetone and acetaldehyde from methyl acetone for the Government. Other firms are Messrs. Evans, Son, Lescher and Webb, of Liverpool; Messrs. Hedley and Co., of Leytonstone (ethyl chloride used as a refrigerator and during the war also largely for narcosis); Messrs. T. Kerfoot and Co., of Bardsley (drugs and rare sugars); and Messrs. Boake, Roberts and Co., of Stratford, manufacturers of acetates, alcohols, aldehydes, esters, solvents for dopes and waterproofing agents, sulphides, &c., for photographers, phosphates for foodstuffs and textiles.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY IN 1917–18.

(Continued from page 123.)

Thermometer Testing. (Mr. W. F. Higgins, Mr. W. Hugo, Miss W. E. Donnelly; Captain G. W. C. Kaye remains on active service).—The number of precision thermometers tested has steadily risen since 1912, the numbers for that year and 1918 being 391 and 701. The increase has been most noted in high-range instruments; commercial undertakings now recognise the need of having such thermometers tested under actual service conditions. The corrections to be made for emergent stem may amount to 30 deg. C., and this point is not sufficiently heeded in steam trials. No further samples of thermometer glass have been submitted for testing; but many new varieties of glass are now being used, and though the quality appears, on the whole, to be fairly good, there is not always sufficient time left between the blowing of the tube from freshly-made glass and its pointing, *i.e.*, marking the fixed points. The Laboratory invites makers to send in sample instruments which could be retained and kept under observation in the Laboratory over a period of years, and specifications have also been drawn up for conducting zero observations; these facilities should be appreciated by thermometer-makers. The number of "Kew" class meterological thermometers was 3,123, against 3,164 in 1916; the figures of 1915 were by about 350 higher.

The number of clinical thermometers tested has grown enormously, the figures for the years 1915-16-17 being 16,137, 24,275, 148,694. Three sections may be distinguished in this testing work. The demands of the trade and of private persons were small, only 5,140 clinical thermometers being submitted against 16,000 or 18,000 before the war, when there was an export trade in these instruments. The 22,300 thermometers of the second section, tested for the War Office, are samples of the instruments supplied to the Army Medical Stores, the batches being accepted or rejected in accordance with the results of the sample tests. In the third section of 122,650 clinical thermometers for the Ministry of Munitions, each instrument is tested individually, and to deal with the three thousands of instruments submitted every week since June, 1916, additions had to be made to the equipment and staff; more than 7,000 thermometers were actually tested in one week. We have described the excellent arrangements made for these tests on previous occasions, and the bath, in which readings are taken, were illustrated in Fig. 10 of Plate XXVIII, and also in Fig. 13 on page 293, of our issue of March 15 last. The difficulties of fairly sampling thermometers, and the advantages of their individual tests are obvious, and it is satisfactory to note that the War Office has also decided to adopt individual testing as soon as the few contracts still running have been completed. The testing, as now conducted with the enlarged equipment, is actually less expensive, moreover, than it was in less busy times. The three new clinical test baths were constructed by Messrs.

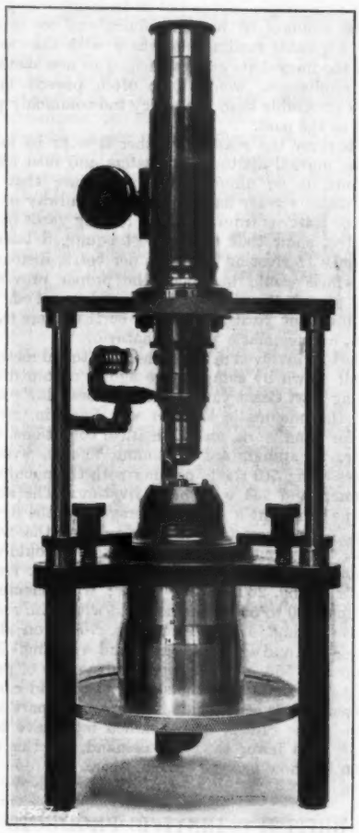


Fig. 3.

Baird and Tatlock, of Hatton Garden, to the old Laboratory design with a few alterations; duplicate cages have been adopted, and the hydraulic cage lift has been enlarged. Each bath can deal with 600 instruments per day. Bundles of the tested thermometers are afterwards dipped by hand into molten wax, and the Laboratory mark is then scratched into the fine coating of wax with the aid of pantagraphs constructed in the Laboratory; during this operation, the tube in question is held by a spring clip, and the simple arrangements for lifting and lowering and renewing the engraving point allow of quick work. As there have been inquiries about the construction of the baths and their use, a publication on the methods and apparatus is being prepared.

Radium and X-Ray Work.—In the continued absence of Dr. Kaye, this work also remains in charge of Mr. Higgins and Miss Donnelly. The use of radium-luminous compounds for aircraft instruments is extending; the 51 samples of radium of high content tested represented an approximate value of 12,000*l.*; the number of samples of radium-luminous compounds tested was 30.

Optics Division. (Messrs. T. Smith, J. Guild, J. S. Anderson, G. C. Steward, R. J. Trump; Misses A. B. Dale, A. Everett, S. E. H. Brewer.) *Telescopes and Binoculars.*—Telescopes and binoculars are mainly responsible for the increase in the total

number of tests conducted: 19,542 in 1915, and 29,825 in 1917, and for the addition to the staff; but the burden of the work lies as much in the special character of some of the tests as in number of apparatus submitted. Difficulties have, moreover, been encountered in securing additional members of the staff, because imperfect eyesight has ruled out some otherwise satisfactory applicants. Certain arrangements made by the authorities in the latter half of 1917 have added to the clerical work. Most of the tests on binoculars and telescopes are now conducted on behalf of the Ministry of ing to the Ministry being provided for despatching the stores to the dockyards. The testing of apparatus for the defence of merchant vessels against submarines has also been taken over. Unlike the apparatus for the Navy, these instruments are largely supplied by firms without previous experience in the branch; though such firms mostly confine themselves to simple patterns, some initial troubles had to be overcome, especially when new firms were participating in the work. A new useful line of tests is that of watertightness, both of the cases and of the instruments themselves.

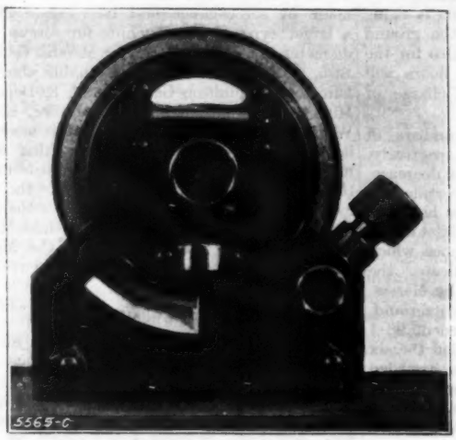
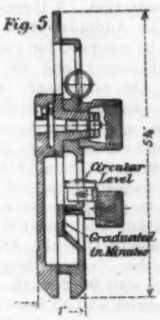


FIG. 4.



FIGS. 4 AND 5. CLINOMETER FOR USE IN MAKING AND TESTING GAUGES.

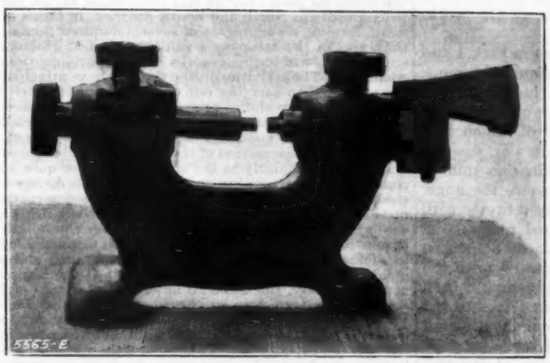
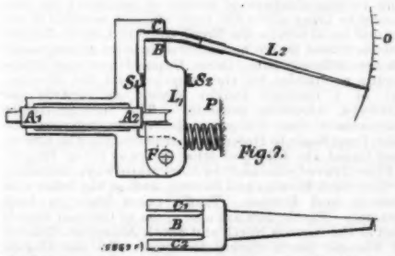


FIG. 6.



Munitions, and no longer for the Admiralty. The actual tests remain the same, but almost every other detail has been changed. Formerly, the contractors were responsible for the delivery of the tested instruments to the dockyards; now their responsibility ceases with the passing of the tests. A store of the Ministry of Munitions has been established in the Optics Division, and, to save space, arrangements have been made so that the issues from the store keep pace with the receipts. But this simplification and saving of space does not extend to time; there is no reduction in the number of returns to be made daily or at intervals, and the packing cases of telescopes have to go back empty to the contractors, if the instruments pass, other cases belong-

Sextants, Optical Glass, General Measurements. — Sextant fittings are now entirely tested in the sextant section, of which Mr. W. J. Boxall is in charge, and not independently, as was previously done. The observations strain the eyes severely; the work has been considerably increased of late, and the increase is likely to last after the war. The determinations of the refractive properties of glasses, for which there is likewise a growing demand, are made on Pulfrich refractometers, which, if properly constructed, *i.e.*, with the highest mechanical skill available, and suitably used, allow of an accuracy attainable by most other methods only with an expenditure of much more time and trouble, it is pointed out; Pulfrich designed his instrument rather for chemical testing than for optical work. Comprehensive theoretical and experimental investigations of the various aspects of refractometry and of types of accurate instruments have been conducted, and proposals for a new form of instrument have been made; these cannot be obtained during the war, however. Notes on the design and use of the Pulfrich refractometer, involving measurements of 2,000 glasses, were, last April, communicated to the Physical Society by Mr. Guild. Some specimens of glass submitted for examination were not especially prepared for that purpose, as they should be for high-accuracy tests; the examination by an immersion method sufficed in all cases for identification, however. As regards general optical calculations and measurements, Mr. T. Smith has brought a number of papers before the Physical and the Optical Societies, describing algebraic methods for economising time in the design of optical instruments. The designer generally wants years of experience to work out a system which, after all, he can hardly explain to a beginner. Mr. Smith has deduced algebraical formulae, by the aid of which a ray in three dimensions can be traced through a system of coaxial refracting surfaces, without the use of tables, so that years of experience can be replaced by a definite course of operations; these researches are being continued. The new precision spherometer, evolved in the department, was described by Mr. Guild before the Optical Society last January; the instrument far exceeds in sensitiveness any other so far known and is yet simple; errors such as the flexure of the lens under test, due to its own weight, and local deformation of the surface in the neighbourhood of the points of support, which are only amenable to a comparatively rough correction in other instruments, can easily be eliminated. Fig. 3 is a photograph of this instrument. The simplest kind of spherometer is merely a tripod stand, in which a micrometer screw is mounted. The plate or lens, the thickness of which is to be measured, is placed on a plane table and the micrometer is lowered into contact; the exact moment of contact may be determined by electrical means, or by, in this instance, watching interference rings. Mr. Guild's

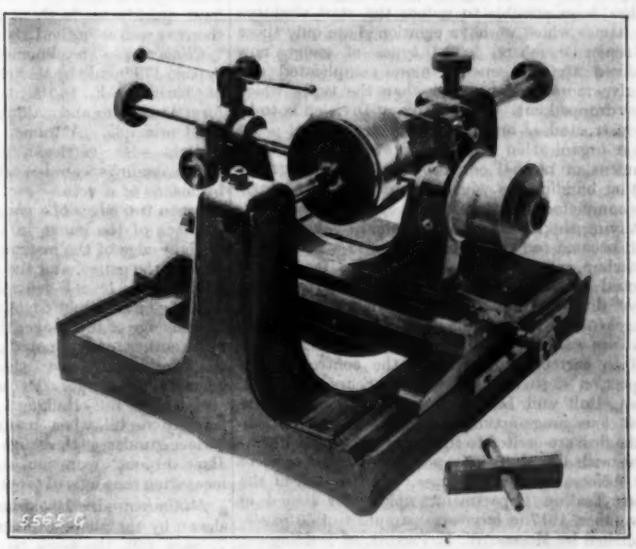


FIG. 8.

instrument is similar to the Aldis spherometer, in which the lens under test rests on three spheres (the adaptor), the micrometer being brought up from below, with the exception that the screw terminates in a spherical surface of quartz (or glass); the radius of curvature of the apex of the screw is 1 mm. As long as the surfaces are approaching, the Newton rings expand rapidly, a new ring forming every half-wave length, but when the lens begins to lift, the expansion of the rings ceases abruptly. The greatest accuracy is obtained by using as the criterion of contact, not this disappearance, but a definite configuration of the rings; in that case there is no error due to the compression of the lens or sphere at the point of contact. The rings are examined by the aid of the microscope on the superstructure, the vertical illuminator of which is above the objective. The illumination is by

means of a small 4-volt lamp, the light of which passes through a piece of Wratten $N^1 = 25$ gelatin filter (red), to render the rings monochromatic. With experience, the instrument is sensitive to 0·0001 mm. The new acquisitions include an interferometer of the Michelson type, modified by Messrs. Adam Hilger, and apparatus, lathe and tools of the late Mr. Duddell.

Tide Prediction. (Mr. W. H. H. Brookes and Miss Cordle).—The continued work for the Indian Tide Tables now comprises preparation of tables for the riverain port of Basrah; on behalf of the Superintendent of the Nautical Almanac Office, machine predictions have also been made for the port of Woosung. The work for the port of Brisbane is continued.

The Library (Miss E. M. Barker.)—The Library has benefited by the acquisition of many of Mr. Duddell's books, and by the gift, by Lady Rücker, of a portion of Sir Arthur Rücker's library.

Metrology (Superintendent, Mr. J. E. Sears, jun., M.A., M.Inst.C.E.; Messrs. S. W. Attwell, B. P. Dudding, E. G. Constable, E. A. Owen, H. L. P. Jolly (on active service), F. H. Rolt, F. A. Gould, V. Stott, H. A. Dear; E. M. Eden, R. Wolfenden, G. A. Tomlinson, W. M. Holmes, W. H. Johnson, E. P. Bennett, A. J. C. Brookes) *Gauge Testing.*—The extraordinary development of the gauge-testing work, which at present forms one of the most important duties of the Laboratory, was dwelt upon by Sir Richard Glazebrook in his lectures on the National Industrial Research Laboratory, (see Engineering, March 8 and 15, 1918). The number of tests performed has grown from 74,707 in 1915, to 233,869 in 1917–18. Yet, owing to the fact that the number of tests of simple types of screw gauges has diminished during the first part of 1918—thanks indirectly to the work of the Laboratory which assists manufacturers in simplifying methods of testing and in training observers—it has been possible to reduce the staff slightly; the names which we have mentioned are only those of senior members. The types of gauges now received are, in general, more complicated and involve more arduous work than the types which have dropped out. The Metrology Division is to be reconstructed as an independent department; but the re-organisation will have to await the re-establishment of normal conditions. The new gauge-testing building, to which we referred last year,* was completed in June of that year. The new gauge-rectifying shop has proved extremely valuable. It soon became too small, however, and a new gauge workshop, covering an area of 10,000 sq. ft., is being erected in the north-west corner of the grounds. Great difficulty was experienced in securing check gauges of the more difficult kind, and additional facilities were needed for the training of mechanics and to correct gauges under the control of the inspection department. Messrs. Sears, Dudding, Eden, Rolt and L. A. Forward have paid visits to various gauge-making firms, and representatives of the firm are invited to the Laboratory for deliberations with the staff. The second enlarged issue of the "Notes on Screw Gauges," by the staff of the Gauge-Testing Department, which was issued in November, 1917 (a large-size pamphlet of 50 pages, published by Messrs. W. F. Parrott, of Teddington, price 2s. 6d.), is an excellent monography on the subject, explaining the principles of gauge-testing and describing the machines, many of which originated in the Laboratory, and their uses. We illustrated some of the new machines last year, and give further descriptions later on in this article. The manifold endeavours of the Laboratory to assist the manufacturers have borne good fruit. While very large percentages of gauges submitted had sometimes to be rejected a year or two ago, especially, of course, with new firms, the average percentage passed is now as high as the average rejections used to be, and reaches 99·9 in some cases.

Most of the general research work has, of course, had to be suspended. The most important work undertaken for the Engineering Standards Committee was the issue of a report on Metric Screw Threads for Aircraft purposes. Mr. Sears has also given considerable attention to a revision of the report on Tolerances for B.S.F. Threads, and Mr. Attwell has conducted an investigation on the design and standardisation of measuring tapes for the tyres and rims of motor vehicles. Measurements are taken with the tape pulled tight when put on the rim or inside the tyre, and although the steel tape has a thickness of 0·01 in. only, a correction has to be made for the thickness, especially as the ends slightly overlap in the measurements.

Glass-volumetric Apparatus.—Arrangements for the calibration glass-volumetric apparatus have been made by the Laboratory in conjunction with the Optical Glass-Ware Department of the Ministry of Munitions, the British Chemical Ware Manufacturers' Association, and the British Laboratory Ware Association. A three-story building is rising near to the Administration building; the ground floor will be reserved for packing, and also for the storage of gauges, and the two upper floors will serve for the new work—which is in charge of Mr. Stott—and also for optical work.

Watches and Chronometers.—The numbers of watches and chronometers, 233 and 73 respectively, against 340 and 118 in 1916–17, mark a decrease. Of the 74 watches presented for class A certificates, 12 failed to pass; the average of passes has kept fairly constant of late, near 70 per cent., whilst it was below 50 mostly till 1913. Of the 42 watches, which obtained the "especially-good" certificate, the first place, with 96·2 marks, was taken by Messrs. Paul Ditisheim, of La Chaux de Fonds, Switzerland, which beat its own (so far highest) record of 96·1 marks (1912); the same firm also supplied the six watches, next-best in order, and was awarded further distinguished places, together with other Swiss firms. The London firm of Messrs. S. Smith and Son appears in the 21st place, with 89·8 marks.

We proceed to the description of the new measuring machines of the Metrology Department. Most of them are original in design, and their accuracy and simplicity and rapidity of operation have quickly made them favourites in the workshops as well as in the Laboratory.

Clinometer.—The clinometer, shown in Figs. 4 and 5, page 179, made by Messrs. Troughton and Simms, of Charlton, S.E., to the design of the Laboratory for use in testing and making gauges, is on the Abney-level principle. A frame, the base of which is a straight edge, carries a pivoted circular dial on which readings can be taken within one minute by means of a vernier arc. To measure the angle between two edges of a gauge it is fixed firmly with the face of the gauge in the vertical plane; the straight edge of the instrument is placed along one edge of the gauge, and the dial is rotated until the bubble of the level is central; a dial reading is then taken. The straight edge is now transferred to the second edge of the gauge, the dial is again adjusted and another reading noted; the difference between the two readings gives the inclination of the two edges of the gauge. The angular scale of the instrument is self-checking. The instrument is extremely useful when making plate gauges on a surface grinder, as the gauge can be set to the correct angle in one operation, and can also serve for measuring the angle of taper gauges.

Minimeter.—In the minimeter for workshop use, shown by the photograph and diagram, Figs. 6 and 7, page 169, the work to be measured is placed between the two anvils, one of which is adjustable in position for work from 0 in. to 2 in., whilst the other can move within a very small range of about 0.001 in. by compressing an adjustable spring which works an indicator playing over a scale on which the ten thousandth of an inch can be read. In Fig. 7 the anvil A_1 A_2 is pressed against the work by the spring P and the lever L_1, whose motion about its fulcrum F is limited by the adjustable stops S_1 and S_2; the end of the lever L_1 is connected to one strip B of the three-strip indicating lever L_2, the other two strips C_1 and C_2 being clamped to the fixed frame of the indicator. Any deviation in the size of the work from the standard is shown by the motion of L_2. The magnification adopted, 300 diameters, can further be increased by optical means. Another vertical arrangement of this device was shown on Fig. 6, of Plate XXVII in our issue of March 15 last. The minimeter is especially intended for comparative measurements of block gauges and Johansson gauges, the manufacture of which has now been taken up by several British firms.

Floating-Micrometer Screw-Diameter Measuring Machine.—The principle of these very handy machines was explained last year (see Engineering, July 8, 1917, page 4). The screw to be measured for diameters is supported between centres and small cylindrical needles or prismatic rods of steel, suspended by threads, are fitted into opposite grooves of the screw and pressed on gently by the measuring micrometer, which is carried on a saddle with V-grooves and is guided on balls. The small machine for screws up to 2 in. in diameter, made by Messrs. Taylor, Taylor and Hobson, is now extensively made by screw-gauge makers. Fig. 8 illustrates a large type of the machine for screws of 7 in. diameter maximum, made by Messrs. G. Cussons, Ltd., of Manchester, and obtainable through the Director of Munition Gauges, A.M. 8, Department, Ministry of Munitions, Queen's House, Kingsway, W.C. The Newall micrometer of this machine and its enlarged thimble admit of taking measurements within 0.0001 in. The standards on which these larger machines are set up take the form of cylinder-ended bars. In order to meet the demand for sets of the small cylinders for these machines during the early part of the war, the Metrology Department took up their making, and over 13,000 sets have been supplied.

(To be continued.)

* See Engineering, July 6, 1917, page 4.

The North German Lloyd.—The German steamer companies, at least the more important ones, have on the whole availed themselves, for reasons which need not be pointed out, of the Government permission to forego the publication of their annual balance sheets during the war. The North German Lloyd makes up for the absence of a regular report by publishing a kind of annual which contains some interesting particulars about the happenings during the year to the company and German shipping generally. The most notable event during the financial year 1917–18 was the seizure of the company's boats in North and South America, in China and Siam, forming an aggregate of several hundred thousand tons, and of the company's valuable piers at Hoboken, and a number of harbour works in the above-mentioned countries. The activities during the year have principally been devoted to carrying out obligations undertaken to the German navy and in preparing for the future, as far as this has been possible under the existing unsettled conditions. The company has taken the most active part in the reconstruction of the German merchant navy, and more particularly in the solution of other questions connected with general reconstruction work. As regards the effects of the new law dealing with the reconstruction of the German mercantile navy, negotiations are proceeding with the leading German yards for the building of new tonnage so as to enable the North German Lloyd to increase its tonnage after the war as much and as quickly as possible. Of the vessels still at the disposal of the company, the Imperial navy had chartered eight steamers for transport to the islands Osel and Dagö. These steamers were altered and made ready for the military requirements; they were chartered a second time for the expedition to Finland and the Aland islands, barring one boat. The company's tonnage department profited from the unprecedented part which the interior waterways had played in general traffic during the war, owing to the shortage of means of transport by rail. In order to bring about the most efficient working of the river and canal service the North German Lloyd's department for towed traffic had entered into an arrangement with the different Elbe, Oder, Upper Weser and Rhine shipping companies for the adoption and the development of a through freight system as regards the waterways, wherever possible. The through-freight arrangements now comprise the traffic between the Rhine, from Basle to Rotterdam–Amsterdam, the Rhine–Weser Canal, the Elbe and other rivers as far as Prague, the Elbe–Trave Canal and the Mark waterways, including the Oder with Breslau and Stettin, and on the other side Hamburg and Bremen. Traffic takes place in both directions. Particulars are also given of German vessels seized in the various North and South American, Chinese and Siamese ports during the year. In the United States, 115 German and Austrian vessels were seized, having an aggregate tonnage of 703,792 tons, belonging to 27 different owners, amongst whom the Hamburg–America line figures for 35 vessels and 283,122 tons, the North German Lloyd for 29 vessels and 234,056 tons, the Hansa Company for 4 boats and 22,276 tons, the German–Australian Company for 6 vessels and 29,120 tons and the Unione Austriaca di Navigazione for 8 vessels and 42,614 tons. In Brazil the North German Lloyd lost 41,637 registered tons gross; in Peru a steamer of 8,226 tons; in Siam 15,297 tons and in Chinese ports 9,872 tons, so that the North German Lloyd's losses through seizure by hostile powers during the year 1917–18 amounted to an aggregate of some 309,000 tons. To this figure must be added seizures in Italian and Portuguese ports in the year 1915–16, amounting, to more than 58,000 tons, and the earlier seizures in English, French, Belgian and other ports. On January 1, 1914, the fleet of the North German Lloyd comprised 982,951 registered tons gross.

LITERATURE.

The Recovery and Re-Manufacture of Waste Paper. A Practical Treatise. By James Strachan, Analytical and Advising Chemist to the Donside Paper Company, Aberdeen. Printed on paper made entirely from regenerated waste paper. Aberdeen: The Albany Press; London: Stonhill and Gillis. [Price 12*s.* 6*d* net.]

In these days when the utilisation of waste is not only a merit but has become a necessity, it is a great pleasure to handle so convincing a proof of economical skill as that presented by this book, and to acknowledge the earnest and well-directed efforts of the author in demonstrating the possibility of turning to profit the neglected accumulations of a material so plentiful and so little regarded as waste paper. In too many ways we are reminded that the situation in the paper trade is serious. The raw material is scarce and is growing scarcer. Production is not equal to the demand owing to the difficulties attending importation in the present crisis and the dislocation of the general machinery of railway transport. The only substitute that home production has to offer is the manufactured paper, that having once served its purpose can be retreated and remanufactured. In proposing such a process a certain amount of ignorant prejudice has to be overcome. The fear that we are getting an inferior article is deep-seated, and there is something offensive in the notion that we are offered a sham or pretence in the place of the genuine substance. The candid admission that the paper under one's eye is one of those despised "shoddy" productions, that it is made entirely from regenerated waste paper without the addition of any new raw materials or even of high-grade waste, should go far to convince us of the injustice of indiscriminate condemnation and remove any such unreasonable objections. The thought may very well occur to anyone who examines the quality of these printed sheets, or of the spare leaves inserted with the view of inviting further critical examination, that paper is immortal. There is apparently no reason why paper similar to that used in this book, which to the uninitiated certainly satisfies all requirements, should not when it has served its purpose be again repulped and regenerated. It seems to have suffered so little in its past history, that it might well continue a useful career.

The author, however, does not take this exaggerated value of the raw material or ignore the disadvantages and difficulties attending its subsequent manufacture. His object is to show precisely what can be done by systematic practice and how operations can be facilitated by scientific method. He calls all those interested in the production of waste paper stock, whether the collector, the paper-stock merchant, or the paper maker, to work intelligently and economically together, that each being aware of the demands and requirements of the other, a successful issue may result. The present time seems eminently suitable for the consideration of such relations since waste paper has acquired a pecuniary value little anticipated in pre-war days. In 1917, the demand was so great and prices soared to such a level, that Government found it necessary to issue a "Schedule of Prices for Waste Paper." This schedule shows that waste paper had actually attained a higher relative value than wood pulp, then quoted at more than five times its normal price. "The higher-grade papers, such as white shavings, ledgers, pamphlets and manillas were about three times their normal prices; softer papers such as woody pamphlets and overissues were from four to seven times, averaging about five times their normal prices; brown materials were from five to eight times, averaging about six times their normal prices." One consequence of this rise in price is that waste papers are now treated with respect; there is a margin of profit that allows of care in the sorting of papers, in the removal of objectionable foreign material, of such inconvenient additions as strawboard cuttings and parchment among white shavings, of grease, sealing wax and other annoying impurities, whose presence in the waste papers has been a source of loss and annoyance to the paper maker. When all waste paper was regarded practically as a drug, little attention was paid to the due preparation of the raw material, but under the new conditions greater attention to these details could be insisted upon, and in the earlier chapters of the book, Mr. Strachan rightly indicates what might be expected from the paper-stock merchant in the way of grading and sorting, with the view of facilitating subsequent operations.

It must not be supposed that the author is the proposer of a brand new scheme. He is careful to point out that more than 100 years ago paper was made out of old waste without any addition of new material, especially by one, Matthias Koops, whose name deserves to be remembered with gratitude, the more so as he laboured well and truly in a cause, that brought him no commercial reward. He may be regarded as the discoverer of the first practical process for the remanufacture of paper from regenerated waste, and the successful processes now working for the achievement of the same object do not differ in any essential particular from the method recommended by Koops. This master did more than make old paper into new. He told others the process, he taught how ink might be removed from the paper and many other useful things. This information he published in a book printed on paper remade from old waste, and the work is extant to day, 117 years later. This is first-rate testimony to the value of his process and the excellence of his manipulation, for we have the author's expert evidence that the paper on which that book is printed "is still good for a few centuries."

Why, then, did not the process flourish? Why has it been the Cinderella of the paper manufacturer, employed only in inferior grades and at times fallen so low that the paper-stock merchant, in the absence of a home market, has been glad to export his waste to foreign countries where it was welcomed? Trade revolution, or times of crisis, seem to have been necessary to resuscitate a manufacture well calculated to provide at a low cost a wood free printing paper, possessing durability and the qualities expected of high-grade stock. The author intimates that the conservation of the paper-maker is to blame. He has uniformly struggled to provide the printer with an immaculate sheet, without spot or blemish, and for this end he has preferred to sell his mill "broke," and allowed his mill "white water" to go unprofitably into the river. The vicissitudes in the past make it hazardous to forecast the future that awaits the production of regenerated stock. We are feeling the pinch of diminished imports now, and are on our good behaviour. Every scrap of written or printed paper has a marked value that ensures its preservation and subsequent use, but notwithstanding this caution, the price of paper in the future will be greater than in the past. It seems certain that the high price will tend to the lowering of the standard of paper for ordinary purposes, leading to the use of "mechanical" wood and consequently to the more rapid deterioration of such papers. A suitable proportion of cotton and linen cellulose may be regarded as essential for a paper that is to possess permanency. Such a paper might be produced at a reasonable cost if various grades of waste paper were properly blended and a percentage of new material added to the waste paper stock.

If we have correctly understood the author, this is the course he would recommend, and his book describes in sufficient detail, from the manufacturer's standpoint, the several processes best adapted to this end, together with the variations that particular conditions may make necessary. There is in general no attempt to enter into theoretical explanations of the causes that produce definite effects, and neither is there any attempt to underrate the difficulties or to deny that extra care is required in the milling. The plan of the book consists in examining first the sources of supply and the manner in which the paper-stock merchant and sorter fulfils his duties. It is intimated pretty clearly that there is considerable room for improvement. The waste paper as delivered to the maker is neither so well graded nor so clean as it should be. A higher standard will probably be reached with higher prices. Competition will be keener and the greater range of prices will bring about more careful selection. This greater care will not be without its influence on the paper manufacture, for the operation of cleaning the raw material constitutes one of the gravest objections that the average paper-maker can urge against the use of the waste material. In Germany the paper-stock merchant is prepared to guarantee his stock absolutely free from foreign materials, and ready for pulping; if similar enterprise were exhibited in this country, the new departure would be heartily welcomed.

The second part describes the mechanical treatment of the waste paper, including dusting and cleaning, re-pulping and beating. The mechanical operations are fairly simple and the machinery is not complicated. Two main principles are kept in view throughout: one is to make the ordinary mill plant as available as possible, avoiding the installation of special machines, the other to insist on the economy of steam. The latter point should not need to be emphasised in these days, but it is to be feared that in many operations, such as the breaking of waste papers, steam is blown in with the intention of hastening the procedure by softening the harder elements in the furnish. Where time is an essential factor in the process, the undue use of steam is not only uneconomical, but will probably have other injurious effects, leading eventually to a waste of material. The chapter on the consumption of power and steam is one that will repay study by those engaged in this branch of manufacture. One conclusion is somewhat unexpected: it appears that though in the preparation of waste paper, the conditions of time, temperature, friction and mechanical pressure will vary greatly according to the apparatus and method employed, yet the number of horse-power hours per hundredweight of finished stuff remains practically the same.

The removal of ink and colour from printed paper, considered in the third section, has given much trouble from the time of Koops, and been the subject of many patents. A number of variables enter the general problem, as the nature of the paper, the composition of the ink, and the diffusion of the varnish through the fibre. In alkaline treatment it is generally assumed that the caustic alkali saponifies and dissolves the oily vehicle of the ink, liberating the solid particles, which may then be removed by washing. The author questions the accuracy of this explanation, and seems to place more reliance on a mechanical loosening of the dried ink by friction of the fibres against each other after saponification of natural rezins and sizing rezins around the cellulose of the fibre. Perhaps the subject would be better understood and more scientifically attacked if the paper-maker would give greater encouragement to the chemist. Hitherto, he has relied on empirical knowledge, but the future it is hoped will see a change, for in several operations the science of the chemist might well guide the mechanical operations of the paper-maker.

In the last section, the author indicates some of the possibilities to be attained by the blending of waste-paper stocks, and acts as a guide to the inexperienced, insisting once again on attention to rigid economy. And herein he is right, for the great recommendation in favour of the use of waste paper as a raw material lies in its cheapness, and this advantage may easily be lost by careless or unintelligent manipulation. All celluloses are not equally suitable for the manufacture of regenerated stock, nor is one inelastic method likely to prove uniformly successful. Constant watchfulness, with alertness to meet varying conditions as they arise, is required from the manufacturer, who would reap a satisfactory reward.

A Text-Book of Physics: For the Use of Students of Science and Engineering. By J. Duncan, Wh.Ex., M.I.Mech.E., and S. G. Starling, B.Sc., A.R.C.Sc. Macmillan and Co., Limited. London: 1918. [Price 15*s.*]

Every year witnesses so many additions, of more or less importance, to the large number of elementary text books on physical science with which able teachers apparently flood the market, that it is difficult to decide in what respect any new publication is superior to those it is intended to replace. This exuberance seems hardly necessary or justifiable for the material is strictly limited by the number of facts, and only the arrangement offers scope for original treatment. The authors, both of whom have already catered for students of

NAVAL PATROL BOAT.

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, ENGINEERS, LONDON.

physical science, defend their action on the ground that the work is needed "to connect more intimately than hitherto the scientific aspects of physics with its modern practical applications." This sentence is not a little vague, and its purpose is not made more definite by the statement, that the success of the attempt must be left to the judgment of the reader, for here the reader is the student, who has not the necessary knowledge required for a trustworthy comparison.

The result is a weighty, well printed, and illustrated volume of over 1,000 pages, and embraces five distinct treatises: Dynamics, Light, Sound, and Magnetism and Electricity. For convenience, and to suit modest purses, each of these can be purchased separately. On other grounds, this is a very desirable arrangement, for many students do not care to carry their general study in physics beyond an elementary stage, afterwards specialising in engineering or some other branch. The information provided is sufficient to meet the requirements of students preparing for intermediate and other examinations of London and other universities, or who are qualifying for appointments in the Army, Navy or Civil Service. In the particular branch of electrical engineering the subject-matter is suitable for those offering themselves for examination (Grade I) in the City and Guilds of London Institute.

It is doubtful whether a student would meet with any great success if he attempted to master any of these subjects without other assistance than these treatises provide, but there is internal evidence to show that such a course is neither contemplated nor recommended by the authors. Experiment proceeds concurrently with theory, and experiments imply laboratory apparatus and teachers. The volume is intended to supplement oral instruction, and is apparently admirably fitted to its purpose. No doubt the variety of apparatus provided in different schools would present some difficulty to the teaching staff, but experience is gradually weeding-out obsolete and unsuitable forms, bringing about a greater degree of uniformity and increasing the possibilities of experimental repetition. On the other hand, experiments go but a little way in eliminating the responsibilities of the teacher. A pupil may manipulate his apparatus, under instruction, with exemplary care and deftness, write out a satisfactory account of the process and yet have little or no appreciation of the principles underlying the experiment or of its educational value. The authors are apparently acquainted with this form of mind, and have guarded against the defect by associating with each exercise a number of questions and problems calculated to probe a little below the surface, and to demand some reasoning power on the part of the pupil. Herein they have followed the best examples illustrated in recent text books. Many of these testing exercises are taken from the papers set in university and other examinations, thus clearly indicating the sufficiency of the treatise to meet the standard of recognised requirements. The selection generally seems to have been determined by a desire to profit by the stimulating effect attaching to real practical problems, and to assist the pupil by insisting upon logical development and exactness of ideas.

It is necessary to call attention to these extracts from examination papers not only as constituting an important feature of the book, but because it is impossible to indicate to any adequate extent the subjects selected for discussion in each section. Many old friends make an appearance and sometimes take on a modernised and possibly an improved dress. Some will think that unbecoming brevity has been meted out to topics which they regard as important, and some be surprised that other subjects have been pursued to what they consider inconvenient lengths. The electrical engineer may wish that the subject of vectors was treated more fully, and the student of optics regret that no mention has been made of optical gratings and the determination of light wave-lengths. The aeronaut may want more information on the viscosity of the atmosphere or the theory of cyclones, and the curious in such matters may think that the phonograph is relegated to an entirely undeserved position. But those who know the difficulty of selection and the impossibility of catering for all sorts and conditions of students, will probably agree that the authors have shown a wise discretion in their choice and very properly have offered abundant opportunities to the teacher to widen the avenue of instruction in any direction that appears desirable to his experience on the requirements of his class of pupils.

BOOKS RECEIVED.

Concrete Engineers' Handbook. Data for the Design and Construction of Plain and Re-inforced Concrete Structures. By George A. Hool, S.B., and Nathan C. Johnson, M.M.E., assisted by S. C. Hollister, B.S. London: Hill Publishing Company, Limited. [Price 25s.]

The Recovery and Re-manufacture of Waste Paper. A Practical Treatise. By James Strachan. Aberdeen: The Albany Press; London: Stonhill and Gillis, 58 Shoe-lane. [Price, 12s. 6d. net, post free.]

How to Work a Spindle Moulder. By W. J. Blackmuir. London: Alfred Haworth and Co., Limited, 84, Leadenhall-street, E.C. 3.

Tabulated Weights of Angle, Tee and Bulb Iron and Steel, and other information for the use of Naval Architects, Shipbuilders and Manufacturers. By Charles H. Jordan, M.I.N.A. Seventh edition, revised and enlarged. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price, 15s. net.]

NAVAL PATROL BOATS.

Recent events, particularly the attacks on Zeebrugge and Ostend, have called attention to the wonderful work done by the C.M.B.'s. These little craft push fearlessly across the German minefields, going in close to the coast, searching for submarines and not shirking a scrap with a destroyer under suitable conditions. They are so light that they can be lifted on board a cruiser and hung in davits, and so fast and nimble that they can choose their own positions, while presenting only a small and elusive target to the guns of larger vessels. They had their origin in Sir John I. Thornycroft's wonderful skill in boat design, and in his painstaking experiments to produce a racing boat which should almost rival a train in speed. As long ago as 1877, that is more than forty years ago, Sir John designed a boat intended to skim on the surface instead of ploughing its way through the water. The invention, however, had to await the advent of the petrol engine before it could be turned to full account, and it was not until 1908 that the skimmer became established as an exciting form of sport. In 1910 it attained its present form.

To our younger naval officers, anxious at all risks to get into contact with the enemy, the skimming boat was a fascinating object. They saw that if it could be modified to suit war conditions it would enlarge their sphere of action and would provide them opportunities such as they are always craving for. That the skimming boat would involve great risks was quite evident, but risks are never counted in the Service when there is good work to be done. Fortunately they were able to gain the assistance of Messrs. Thornycroft and Co., Limited, whose design was approved and supervised by the Admiralty technical officers. After some experiments the highly successful boats now in use were produced, and many wonderful feats have been accomplished by them. The curtain of secrecy was lifted a little after the Zeebrugge raid, but generally nothing is published, and the Naval Honours List does not always refer to the particular actions for which decorations have been awarded. Many, however, have already been given to the Commanders of these boats.

It was a somewhat similar type of boat which was used by Lieutenant Reiso, of the Italian Navy, in torpedoing an Austrian battleship, and doubtless others of our Allies are building such craft. We hear much of American motor boats, but so far these fast craft used by us have all been built in this country from the designs of Sir John Thornycroft, and their general appearance under way can be gathered from the photograph on this page.

Engineering Activity in Sweden.—A new company has been formed in Helsingborg under the style of the Helsingborg Engineering Works, with a minimum capital of 3,000,000 kr., and a maximum of 9,000,000 kr. The company takes over an old concern, and will also undertake the manufacture of electric motors. The old works and plants will be materially extended. The Norberg Mining Company has decided to increase its capital from 3,300,000 kr. to 4,950,000 kr.

CONNECTING SUBWAY TUNNEL TUBES IN QUICKSAND.*

The Henry-street Station, Brooklyn, on Section 3, Route 48, of the New York Subway System, is at the east end of the East River tunnels that have been driven, under compressed air, with two single-track cast-iron shell tubes about 17½ ft. in outside diameter and 7½ ft. apart in the clear of this point. The station has an island platform which connects the two tubes that had previously been built at this point with segmental lining plates about 26 in. long longitudinally and 6 ft. wide circumferentially, secured by bolts through interior flanges on all sides. Each ring of the tunnel lining was made with nine segments and a key, all held in position by the heavy balanced external pressure on the soft soil. The construction of the station made it necessary to remove three segments in each of 320 rings of each tunnel, to connect two special segments in each of these rings to the heavy structural steel framework, and to build the concrete roof and platform without impairing the integrity of the tunnel tubes and without endangering the stability of the different parts of the work under the extremely heavy pressure or allowing any settlement of the tunnel tubes on adjacent buildings.

The requirements for the structure were specified by the engineering department of the Public Service Commission, under whose direction the work was designed and executed. The methods and details of operation were devised by John F. O'Rourke, chief engineer of the Flinn-O'Rourke Company, who did the work.

The work, which was carefully planned in six successive operations, consisted essentially of placing heavy posts in the tubes to carry the top of the tubes, then driving a top heading on the centre line between tubes, also partly carried on the line of posts and bracing its timbering to the ground between the tubes, excavating the bottom underneath heading, bracing the bottoms of the tubes with horizontal struts between their adjacent and opposite sides, removing portions of the adjacent sides of the tubes, building in successive stages a heavy longitudinal frame work of structural steel girders and columns connecting the tubes, and filling in a solid mass of concrete on the top and bottom of the framework, thus transforming several hundred feet of separate parallel tubes to a compound structure having cross-sections with horizontal flat top and bottom sides and curved ends, each of them composed of more than a semi-circle of the original tube segments.

First Operation, Driving Top Heading.—Construction was commenced near the Henry-street shaft, Brooklyn, where a short tunnel was drifted to the required position and the top heading commenced between and slightly above the two tunnel tubes. This heading, driven under atmospheric pressure, had a total width of about 21 ft. and height of 8 ft. The excavation was done by the ordinary poling board method, and timbered with 12-in. by 12-in. posts, caps, and transverse sills 4 ft. 4 in. apart longitudinally, heavily wedged to take up possible settlement before it could start. The bottom sills, about 9 ft. 10 in. long, were bevelled at both ends to correspond with the surface of the adjacent tunnel tubes against which they are securely wedged. The centre sections of the caps were accurately set to have only 8 in. bearing on each of the centre vertical posts and their ends were bevelled 6 in. to slope upward toward the centre of the heading. (See 1st step, overleaf.) The end sections of the caps were bevelled to overlap the centre sections supported on vertical posts 8 ft. apart and their outer ends were supported on short inclined posts radial to the tunnel tubes on which they took bearing immediately above the line of posts in the tubes. The excavation was in flowing sand carefully bulkheaded. As it advanced, the roof was thoroughly grouted.

In each of the tunnel tubes the lines of posts were constructed as follows. Longitudinal 12-in. by 12-in. sills were laid on the invert 14 in. clear of the centre line, and supported by filler blocks bearing against the plate webs and by steel plates and wedged bearings over the segment flanges. These sills supported 12-in. by 12-in. vertical posts 4 ft. 4 in. apart in the planes of the timbering bents of the heading. The upper ends of the posts engaged longitudinal sills bearing against the tunnel lining in the same manner as the bottom sills, and like them were connected to the vertical posts with pairs of wooden scabs. Horizontal brackets bolted to the posts 4 ft. or 5 ft. below the tops of the tubes provided support for working platforms 6 ft. wide for the convenience of the men who adjusted the wedge bearings at the tops of the posts.

Second Operation, Driving Bottom Heading.—After the completion of the top heading, a 3-in. by 12-in. longitudinal plank was spiked to the sills on the centre line, and a 30-in. longitudinal Bethlehem 200-lb. I-beam needle beam 35 ft. long was set on the sill just inside each of the centre posts. Excavation of the lower heading was then commenced between the tunnel tubes, and over it the roof of the upper heading was supported by short vertical shores engaging the caps and bearing on the needle beams with pump screws. (See 2nd step).

The excavation of the lower heading was carried 8 in. below subgrave, a concrete bottom was placed and longitudinal bottom sills were laid on it to receive the 12-in. by 12-in. vertical posts engaging the transverse sills of the upper heading and wedged against the tunnel shell at the springing line. In each bent these posts are braced by temporary horizontal transverse 12-in. by 12-in. struts at springing line, except that every third strut is placed 6 in. lower to clear subsequent longitudinal bracing.

As the excavation of the lower heading advanced, the needle beams were wedged tightly against the transverse sills of the upper heading in two panels in the rear of the excavation and in two panels in front of the excavation, leaving two sills unwedged at the point of excavation where the roof load was carried on the pump screws, thus relieving the sills at this point from load by the needle beam and concentrating the needle beam loads on sills that were firmly supported. As the excavation advanced and the pump screws were released and set one bent ahead the needle beams were correspondingly advanced on the sills and the same system of wedging and jacking was continued.

Third Operation, Bracing Outside Walls, and Tubes and Laying Concrete Bottom.—In the spaces between temporary transverse struts at springing line, corresponding to alternate segments of the tunnel shell, the segments at the springing line were removed and long horizontal transverse 12-in. by 12-in. struts alternately 5½ ft. and 7½ ft. apart were set at the springing line

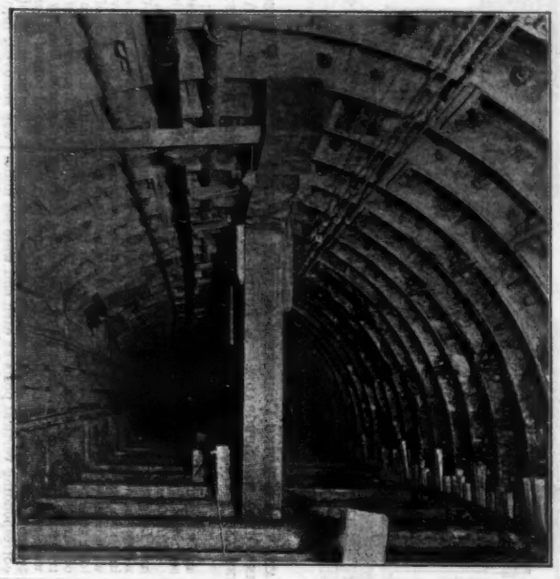


Fig. 1. Vertical Shores and Timbering Wedged against Tunnel Rings.

Fig. 2. Needle Beams in Position in Heading.

Fig. 3. View in Heading on Top of Tunnel Tubes.

Fig. 4. Timbering for Drifts Shored up on Tunnel Tubes.

* We are indebted to our New York contemporary, *Contracting*, for this account of a very interesting work.

CONNECTING SUBWAY TUNNELS IN QUICKSAND; HENRY STREET STATION, BROOKLYN, U.S.A.

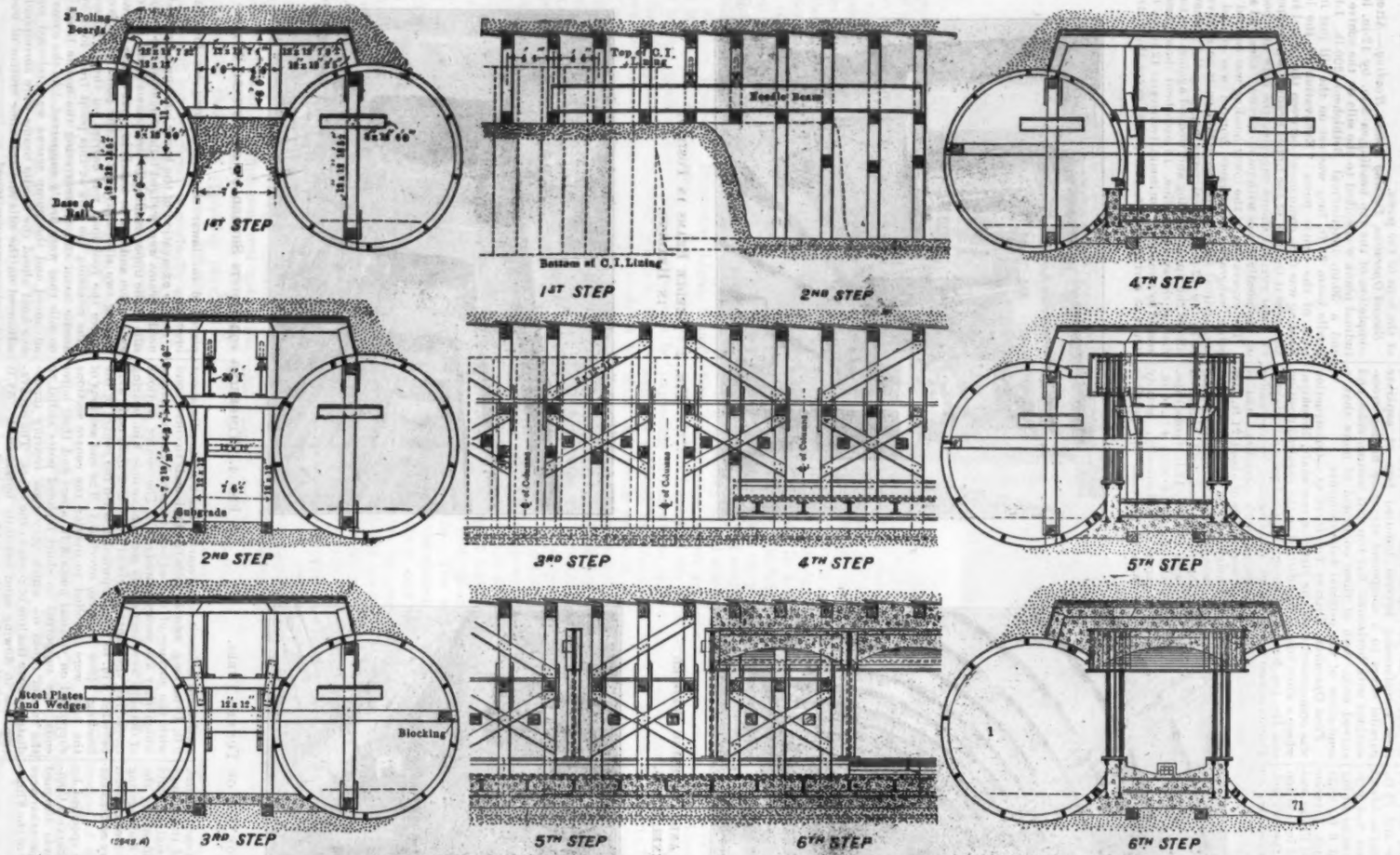


FIG. 5. SUCCESSIVE OPERATIONS IN QUICKSAND FOR THE CONSTRUCTION OF HENRY-STREET STATION CONNECTING COMPLETED SUBWAY TUNNEL TUBES. 1. MATERIAL DRIFTED OUT ABOVE TUNNEL TUBES AND ROOF SUPPORTED FROM THEM. 2. EXCAVATION CONTINUED BETWEEN TUBES TO SUBGRADE. 3. TUBES BRACED AND SECTIONS OF ADJACENT SIDES REMOVED. 4. BOTTOM LONGITUDINAL GIRDERS CONNECTED TO TUNNEL LINING. 5. VERTICAL COLUMNS AND UPPER GIRDERS ERECTED. 6. ROOF CONCRETED AND DRIFT BACKFILLED.

reaching through both tubes to their outer walls where they had steel plate bearings and adjustment wedges against continuous 12-in. by 12-in. longitudinal timbers bearing on the segment flanges and on blockings to their webs. Adjustment wedges were tightly driven, the temporary short struts between the long struts were removed, and the vertical posts in the headings were braced by two 3-in. by 12-in. planks crossing the two panels and leaving single panels unbraced between the sets of bracing. (See 3rd step.)

Additional 3-in. by 12-in. longitudinal planks were also spiked to the sills of the upper heading in place of the needle beams as the latter were advanced. Care was taken to break joints of longitudinal struts on the sills each side of the locations of the permanent steel columns. While the bracing was being done, the bottom of the lower heading was concreted and carefully finished to provide a seat for the permanent longitudinal girder sills.

Fourth Operation, Placing and Concreting Permanent Longitudinal Girder Sills.—The remaining segments of the two tunnel tubes at the level of the concrete floor were removed and the two double-web longitudinal girder sills in sections about 15 ft. long were seated on the concrete and connected to the flanges of the special tunnel segments prepared to receive them. The sills were connected 4 ft. 4 in. apart by transverse struts consisting of pairs of 6-in. channels back to back, riveted to them just above their bottom flanges, and the space between the webs of the longitudinal sills and between the transverse struts were concreted up to 3 in. above the tops of the struts. (See 4th step.)

The top flanges of the longitudinal sills were blocked and wedged tightly against the lower edges of the tunnel segments.

Fifth Operation, Erecting Vertical Forms and Transverse and Longitudinal Roof Girders.—At points 30 ft. apart where the longitudinal X-bracing is omitted in the timbering, two more segments next above the floor concrete were removed from the tunnel lining rings between the long transverse struts to give clearance for the erection of the transverse bents of the station framing. The transverse roof girders, about 14 ft. long and 4 ft. deep, were raised to the required height in these openings and temporarily supported on shores and lagging until the corresponding vertical posts at each end were set under them, seated in pockets left in the concreting filling and riveted to the webs of the longitudinal girders. The ends of the transverse girders were temporarily blocked and wedged against the flanges of the upper segments of tunnel lining and the girders were riveted to the columns.

Sixth Operation, Erecting Longitudinal Roof Girders and Completing Concrete Work.—Longitudinal plate girders 16 ft. long and 4 ft. deep were riveted across the ends of the transverse roof girders and riveted to the bevelled flanges of the special segments of the tunnel lining designed to receive them, thus completing the steel framework of the station structure and providing permanent bracing to maintain the stability of the intersected tunnel rings. (See 6th step.)

The upper tier of diagonal bracing of the timber bents was removed, forms for jack arches were set and concreted, and more concrete was placed there until all the space between the roof girders and in the top heading was filled, making a solid mass of concrete in which the

roof timbers, poling boards, and side posts of the upper heading are permanently embedded.

After the roof concrete was sufficiently strong to carry the superimposed load, the remainder of the timbering and all the tunnel lining segments between the roof and floor were removed, ducts were laid on the invert, and the concreting was finished, completing the main structure operations.

ELECTRIC ARC WELDING.*

By ROBERT E. KINKEAD.†

IN presenting a paper to a body of engineers on the subject of electric welding, it seems advisable to treat the subject in general terms and to cover, so far as possible, the whole field, allowing points of particular interest to come up in the discussion to follow.

There are two general kinds of welding, namely, that which requires heat and mechanical pressure and that which requires heat only. The first kind of welding includes forge welding, electric butt and spot welding and electro-percussive welding. The second kind of welding includes the thermit welding process, the oxy-acetylene and electric arc processes. The latter two processes are called autogenous welding processes. An autogenous weld is made by heating the metals to a liquid state and pouring them together into a homogeneous molten mass and allowing them to cool. The source of the heat required to melt the metal does not alter the principle of the operation, but does necessitate different methods of performing it. With very few exceptions the same operations may be accomplished with either the oxy-acetylene or electric arc process. The electric arc has a higher temperature than the oxy-acetylene flame and the great part of its heat is produced in an extremely localised area *within* the metal to be welded rather than external to it, as is the case in the oxy-acetylene flame. The heat of the arc being produced in the metal is more efficiently used so that it is possible to do at least three times as much welding with a given amount of heat produced by the electric arc as would be possible with the same amount of heat produced by the gas process. The approximate heat quantities involved in the welding arc are easily calculated from this formula:

$$H \text{ equals } \frac{E \times I}{1{,}000} \times T \times 3{,}413,$$

H equals heat in British thermal units.
E equals average voltage across arc.
I equals average current in the arc circuit.
T equals time arc is in operation in hours.

The factor 3,413 is the heat equivalent of one kw.-hour energy in British thermal units.

The heat liberated by the oxy-acetylene flame may be calculated knowing that a 1 cub. ft. of an oxy-acetylene mixture gives about 1,550 British thermal units of heat.

The cost of producing a unit of heat for autogenous welding with the present prices of gas and electric power is about in a ratio of gas, 3; electric, 1. With an "effectiveness" factor of about 1 to 3 in the use of the two processes, it is evident that the cost of gas is in the neighbourhood of nine times the cost of electric power doing the same work.

Up to the present time the electric arc welding process has been used almost exclusively in the welding of steel. The very great localisation of heat of the arc gives it a marked advantage over the oxy-acetylene plant for welding on boiler plate and sheet metal. The difficulties arising from expansion and contraction with the attendant buckling of the plate and cracking of the weld encountered in the use of the gas process are, to a certain extent, eliminated in the arc process due to this localisation of the heat.

Gray iron may be welded with the carbon arc welding process, but the operation is somewhat more difficult than welding with the gas flame and perhaps requires more skill on the part of the operator.

The commercial applications of the electric arc welding process are very interesting. By the use of the process it has been possible to accomplish certain things which were not possible before. It is often possible, by its use, to accomplish in a few hours essentially the same results which a few years ago would have required ten times the labour and perhaps ten times the actual working time. The use of electric power for autogenous welding is another triumph for electricity.

One of the most interesting applications of the electric arc welding process is in the locomotive shops and round houses of the country. This is an application which is growing in importance daily. The steam locomotive is merely a large number of pieces of steel bolted or riveted together. Each piece and the whole is subjected to the most severe stresses. Most of the parts are subjected to excessive wear, and the boiler is worked to the limit of its capacity under most unfavourable conditions. Under present war-time conditions of railroad traffic motive power is being kept on the road double the number of miles that was considered possible two years ago, before finally coming back to the locomotive shop. The electric arc welding process is used to weld the flues into the back-flue-sheet of the boiler; to weld cracks and patches in the fire-box; to weld in new sections of the flue-sheet, door-sheet or side-sheets. Broken frames are welded in from six to ten hours without dismantling the engine. Worn links, guides, hangers, &c., are built up with new metal, re-machined and put into service in a few hours time. Worn flanges on the drive wheels are built up without dropping the wheels and the engine is put in service without turning the tyre.

I submit copy of a paper presented by E. Wanamaker, electrical engineer of the Rock Island lines, in which he presents some very interesting facts in this connection. One of the most interesting is that by the use of the welding process they have obtained from their present motive power equipment the same service that they would have obtained with 23 additional engines, but without the welding equipment. Mr. Wanamaker's paper on "War and Welding" is one which every railroad man in this country ought to read. If there is anyone who has any doubt as to what the engineers of this country must do as their share to help win the war, a study of the results which Mr. Wanamaker has obtained is to be recommended.

(*Copy of Paper.*)

WAR AND WELDING.

By MR. E. WANAMAKER, Electrical Engineer, Rock Island Lines.

In addressing the Western Railway Club on the subject of operating economy, I feel that it is entirely unnecessary to enumerate the reasons why it is imperative for the railway systems of the country to exert the maximum effort to move the freight of the country with the greatest possible dispatch. That is a lesson which we have learned as the result of the campaigns which have already been fought in Europe. We have the example of the remarkable, effectiveness in transportation which has been reached by Germany, and, on the other hand, have witnessed the most complete failure of the Russian military effort, due to lack of proper transportation facilities. The paper presented to this club on September 18 by Mr. W. L. Park, vice-president of the Illinois Central Railway Company, together with the discussion following it, deals with this subject in a very excellent manner.

So far as we can see at present, the railroads of the country will not be burdened as seriously, due to the necessity of transporting the armed forces for the nation, as they will be burdened with the transportation of food for the seaports, and the multitude of commodities which require transportation to be manufactured into munitions of war, and which later must be delivered to a seaport for ocean transportation to the theare of war. This latter transportation service is in no way different in quality from the ordinary industrial transportation service which the carriers must render in time of peace. However, there is an enormous difference in the quantity of service required. The effectiveness of the nation in the war is a function of the time required to put effective fighting units in the field and keep them properly supplied with food and the implements of war. The ability of the railroads to meet the demands upon their transportation facilities will be an important factor in the time required for the nation to become effective on the battle fronts.

This discussion deals with one way of getting more transportation service out of the railway equipment in existence at the present time. Efforts spent in this direction are as patriotic and necessary as can be imagined. I do not wish to depreciate for a moment the patriotism of the man who puts on the uniform and risks his life "to make the world safe for democracy." I do insist, however, that the patriotism of the civilians, particularly of the mechanical engineers in railway service, must not stop with the more or less superficial demonstration of loyalty to the stars and stripes. Those of us who cannot go to the fighting front must use the best of our abilities to get service, "and still more service," to paraphrase Lloyd George's quotation, from the motive power and rolling stock of the nation's railway systems.

The growing possibilities of the welding processes in motive power and rolling stock maintenance have been a source of amazement to every railway man who has come in contact with the practice. From an engineering standpoint, the welding processes are particularly interesting. In the matter of cutting metal the improvement in practice brought about by the introduction of the oxygen torch is particularly great. Only a few years ago the shearing of plates was the only method used for cutting plates, &c., to the proper size for manufacture and repair purposes. It was slow, inaccurate and wasteful. The cutting of large holes and special shapes after the plate had become a part of a boiler or machine had to be accompanied with drill and chipping hammer. The cutting of rivet heads, bolts and nuts was an operation which took an unreasonable length of time and required an expenditure of labour all out of proportion with the results accomplished. In such operations the application of the oxygen cutting processes saved from 50 to 90 per cent. of the time required to perform the operation. Yet I regret to state that in many of our locomotive shops and car yards the old practices are still followed, and our man power for this cause has not produced the maximum result.

The matter of fastening two pieces of metal together is one of the fundamental problems of mechanical engineering, since all machines are made up merely of so many pieces of metal fastened together. The rivet is almost as old as the hammer and anvil. The threaded bolt and nut, as compared with the rivet, are recent inventions. The welded fastening came down to us from antiquity. The welded fastening has always been looked upon as a stronger joint than the riveted or bolted fastening. The reason that it was never more widely used until recent years has been due to the fact that only one way of making a welded joint was known, and that this was not applicable, except to a limited range of joints. As a general proposition the riveted joint, or bolted joint, has a tensile strength which is considerably less than the tensile strength of the original piece, while the welded joint is as strong as the original section. For instance, two pieces of boiler plate may be riveted together with four rows of rivets and double straps, and the tensile strength of the joint will not exceed 85 per cent. of the strength of the original plate, yet it is quite a simple matter to weld a joint in the same plate, either by the old forge welding processes or by later autogenous welding processes, and obtain a joint that is as high in tensile strength as the original plate. The reason more of such welded joints have not been produced prior to the introduction of the autogenous welding processes has been due entirely to the difficulty experienced in applying a forge weld to the structures made of plate. The welded joint, and particularly the butt welded joint made by an autogenous welding process offers greater strength, with a thickness for practical purposes equal to the thickness of the original plate. This is a feat in mechanical engineering which has been unheralded, but ranks with the introduction of the power hammer, the pneumatic tool, and other great strides in mechanical engineering progress.

There was a time when worn surfaces of the steel parts in a machine made it necessary to scrap those parts. There was no method, aside from the using of chafing plates, of avoiding this practice. The wearing of a fraction of a cubic inch of metal from one of the wearing surfaces of a steel part made it necessary to scrap the labour investment in that particular part entirely. It was only with the introduction of the autogenous welding processes that it became possible to stop this economic waste. This also ranks as an important engineering achievement, and it has only been in the last three years that the possibilities in this direction have begun to be realised. While it has not been possible to apply this salvage to cast-iron parts to any great extent, the tendency has been towards the introduction of steel castings in place of grey iron castings to accomplish the desired result.

The repair of broken members of a machine has been another important work of the autogenous welding process. Prior to their introduction certain steel part could be welded in the forge fire, but the range of the work was very limited and in many cases its cost equal to the cost of a new part. Now, however, with the exception of cast-iron parts, the failure of which would bring death and destruction, practically all parts of a machine which break may be safely repaired.

Viewed from the perspective of the last 50 years, the achievements made possible by the autogenous welding processes in the last five years are probably the most remarkable of any in the mechanical field. It is my purpose to point out so far as is possible how far these new practices may be utilised on steam railways to enable the railway systems of the country to meet the present emergency in the matter of service demanded from motive power and rolling stock equipment. It seems advisable to preface my remarks on the newer processes with a short discussion of their relationship to the older and more established practices.

Forge welding has probably been practiced ever since man had intelligence enough to construct a crude anvil and a hammer. It rests on the fact that when two pieces of iron are raised to such temperature that they become plastic, they may be forged together and will become, at the junction, a homogeneous mass. The art of forging depends upon three things:—

1. The surfaces which are to be welded together must be clean so that the molecules of iron may come into intimate contact during the operation.

2. The temperature of the metals must be such that cohesion of the molecules may take place, but must not be high enough to depreciate the physical properties of the metals.

3. The mechanical pressure must be applied in such a manner as to bring the molecules into such intimate contact that cohesion will take place.

The first of the new welding processes, which may properly be called autogenous processes, since the welding takes place more or less automatically, was the thermit welding process. In this process the metals to be welded, together with the additional quantity of metal of approximately the same composition, are heated to a liquid state by a chemical reaction, so that cohesion takes place while they are in the molten state, *without the mechanical pressure.* This process found a wide application in the repair of broken steel parts on the railroads and the economy which resulted from its use, without doubt aggregated millions of dollars.

Welding with the oxygen and fuel gas flame was the first widely used autogenous welding process. In this case the heat for welding is produced by the chemical union of oxygen and some fuel gas, such as acetylene. The gas flame as a tool in the railway shop is best described by the once fictitious term, "putting on tool." The parts to be welded are heated to a liquid state at their surfaces by the heat of a flame and the metal to be added is melted simultaneously. The union, or fusion, takes place and the metal in the joint cools off, leaving a homogeneous mass which we call a weld. Since every one is more or less familiar with the gas welding process, this paper will deal primarily with the electric welding process and an extended discussion of the gas process will be omitted. It is sufficient to state that at the present moment the essential difference is in the method of producing the heat for welding, rather than in the fundamental principles involved.

In passing it may be stated that there is a form of electric welding which is not an autogenous method of welding, but which is increasing in prominence in railway work. I refer to butt or spot welding work. In these processes both heat and pressure are used to produce the weld. The heat is produced by the resistance offered to the passage of an electric current through the pieces to be welded. The temperature is raised to the point at which the metals become plastic and the pressure applied. In principle the processes are identical to the

* Paper presented to the Cleveland (U.S.) Engineering Society, December 11, 1917.

† Engineer of welding, The Lincoln Electric Company, Cleveland, Ohio.

forge welding process. Butt welding as applied to the safe ending of flues offers an attractive saving and will undoubtedly become standard practice on all railways in the near future.

There are two kinds of electric arc welding, known respectively as carbon electrode welding and metal electrode welding. In the former an arc is drawn between a carbon electrode and the piece to be welded and the metal to be added fed into the arc in the form of a "melt bar." This process is not used extensively in railway work, due to the fact that welding may only be done in the horizontal plane in this manner and that the work is in general inferior to that which is possible with the metal electrode process.

The metal electrode process uses, as the name implies, a metal electrode—the arc being drawn between the electrode and the piece being welded. The heat of the arc melts the metal of the piece and the metal of the electrode simultaneously. As the metal of the electrode melts it is drawn across the arc to the molten metal of the piece where a complete and homogeneous union is formed, which we call an autogenous weld. I say the metal of the electrode is *drawn* across the arc rather than that it falls through the arc advisedly, since it will flow straight overhead as well as straight downward. The temperature of the arc is extremely high at its centre, actually vaporising the metal to form the visible arc. With the exception of work with certain electrodes (manganese steel and slag-covered electrodes), the electrode is always made the cathode or negative—that is, the current of electricity flows *from* the piece being welded to the metal electrode. The reason for this practice is that the greatest amount of heat in an electric arc is liberated at the point at which the current passes from the solid medium to the heated vapour of the arc. Since the metal of the piece has more mass, and conducts the heat away from the point at which the welding is being done more rapidly than the electrode, it is desirable to have the greatest amount of heat on the piece. Due to the composition of the managanese and slag-coated electrodes, it is necessary to make these electrodes the positive.

The characteristic of the wire which is used for the metal electrode is an important matter. A dead soft steel wire has been found entirely satisfactory for this work. Not all dead soft steel wire, however, works well in the arc. Uniform mechanical treatment in manufacture and careful annealing are required to secure the best results. This wire can be secured at the present time at a cost ranging from approximately 6 cents to 10 cents per lb. Good welding wire may be relied upon to give metal in the weld which has a tensile strength of from 50,000 to 55,000 lb. per square inch. The deposited metal is very soft and easily machined, although it is without appreciable elasticity. When properly deposited, the metal is practically free from blow holes and slag inclusions, although a certain amount of oxide in solution is unavoidable. Except for the absence of elasticity, the deposited metal is of the nature of cast steel.

The voltage required for metal electrode welding is approximately 20 volts and direct current power is necessary. The various types of welding equipment are merely different plans for rendering available a rather heavy current at this voltage, and the power economy of the several systems for obtaining this result varies over a wide range. Since we have gone into the matter on a rather extensive scale on the Rock Islands Lines, it may be of interest to analyse briefly the conditions which led us to decide on a certain type of equipment.

A little over five years ago, the Rock Island installed four electric welding units of the first type that had been manufactured in this country. During the time since their purchase, and up to the present, we have been quietly investigating and developing our electric welding practice. As a result, we found that to obtain a suitable welding system it was necessary that we secure a light, compact, portable unit, of few parts, and of extreme simplicity, which would be entirely free from complicated mechanical regulating devices.

In planning the installation, a careful analysis was made of the service which is demanded of electric welding equipment in railroad shops and engine houses, and an attempt was made to design an installation which would show under such conditions maximum reliability and flexibility with minimum installation and operating expense. It appeared certain that the welding process would find a wider field of application than was apparent at that time, and the installation was made in such a manner as to lend itself readily to enlargement should that become necessary. And I might say here that in view of our experience and results we were indeed fortunate in rendering an expansion of the welding facilities easy. The lack of standardisation of operations in the practice at that time made it extremely difficult to predict accurately the size of installations which would be required at the various points on the system, so it appeared desirable to instal equipment which could be moved from one point to another, until proper distribution could be obtained.

It was considered particularly desirable to have the arc welding equipment available at all points in the shops and engine houses, since it was quite evident that the advantage of the low cost of the arc welding process would be lost if, for instance, the locomotive had to be moved from a haphazard location to a point where the welding power would be available. These features led to an analysis of distributing systems for the welding power and showed the necessity of using portable arc welding equipment, similar, so far as possible, to the portable gas welding outfits. With the total capacity divided at each shop among several units, it appeared certain that so long as power was available, there would not be a complete shutdown of the welding equipment. Each operator would be entirely independent of the others, although as many as necessary could be concentrated on any engine or job in the shop.

The operating economy, while not a deciding factor, was important, since at some shops the power plants were loaded to their capacity, and at other points the power purchased from small central stations was rather dear. Under these conditions, the variable voltage type of equipment was considered the best because this type eliminated the resistance ballast from the arc circuit, thus increasing the power economy of the units to such a degree that a single operator unit may be operated from a power line large enough to carry a 5 h.p. motor.

As a result of the analysis of the requirements of the shops and car repair yards, 33 individual unit welders were installed, 10 of which were mounted on brackets on columns in the largest locomotive shop, while the other 23 were portable machines weighing complete with truck, approximately, 1,700 lb. All of these units are motor generators having inherent regulation and an arc stabiliser. The portable units are equipped with ball bearings which require lubrication about once in six months. Part of the machines are equipped with 230-volt direct-current motors and part with 440-volt three-phase, 60-cycle motors, these two kinds of power being the standard on the Rock Island Lines.

I might say in passing that at the time we purchased the portable equipment the manufacturers of the welding outfit were only able to furnish a standard industrial truck for this purpose. We have since found from actual practice exactly what is required in this line and are developing a standard truck which meets the requirements much better than an ordinary industrial truck. One of the manufacturers will shortly offer this development on the market as standard equipment.

The portable unit system was found to be from 30 per cent. to 40 per cent. lower in total initial installed cost due to the elimination of the low voltage distributing system.

With a system such as has been installed on the Rock Island Lines, with portable welders, the installation of electric welding equipment is converted into a system proposition rather than a series of plants to take care of certain shops or terminals. The plan is extraordinarily flexible and has many desirable features that would be impossible to obtain with any other plan or type of equipment. For instance, if it is found that one or more welders are needed at some shop, it is very probable that some can be transferred from another point which has more than can be used to advantage at that particular time, it is only necessary to pull the units to be transferred into a car, block them substantially, and bill to the point where needed. Immediately on receipt they are ready for operation. We have taken advantage of this feature of the plan on a number of occasions and have been able to relieve congestion of work and get engines into service considerably ahead of the time originally estimated. However, officials at all points are very reluctant to surrender any of their welding equipment, claiming that they have not nearly enough as it is.

We have succeeded in making the application of the electric arc welding process on the Rock Island Lines a system proposition not only in the matter of the apparatus itself, but also in its operation. It appeared to us that some roads were using the process in a more or less haphazard manner, leaving the matter to the fancy of the operator. It seemed to us that in going into the practice it would be advisable to throw the whole force of the operating organisation into it to get the most out of it. The successful application of the process requires the combination of three factors—engineering knowledge, craftsman's skill, enthusiasm. The direction of the practice of our road rests with the engineering staff of the mechanical department; the actual operation is done by skilled members of the boilermakers', pipefitters', machinists' and blacksmiths' crafts. We do not employ novices or apprentices in this work. Only the best men of the respective crafts are picked for operators. It has been plain from the start that only the highest type of craftsmen could secure the results we want and we have witnessed the growth of a considerable amount of pride and enthusiasm in the work among our operators. Even with the best of equipment and facilities for welding, we recognise the fact that it is absolutely necessary that only skilled operators be employed.

Under competent direction, the skilled and enthusiastic operator will seldom make serious blunders in the application of the process. We have found few of the "know it all" type of men among our skilled craftsmen in this work, whereas I am quite certain some roads have had great difficulties in this line among operators made of green apprentices and "handy men." Further, we have found that the skilled craftsman, who is enthusiastic about the process, is continually finding new and profitable fields for its application.

The connecting link between the engineering staff and the operators is the Supervisor of Welding, who is fully informed on the range of approved applications and is also the most expert operator on the road. He is continually travelling between the shops keeping the practice of each up to date and seeing that everything runs smoothly. The operators at local points are under the supervision of the foremen and master mechanics in exactly the same manner as lathe operators or other craftsmen.

Due to the shortage of time, it is not within the scope of this paper to discuss in detail the necessary instructions for properly operating a complete welding system. On the Rock Island it was found essential that we compile a complete set of welding instructions, which comprise some 30 typewritten pages. It is the purpose of this set of instructions to standardise the major operations as far as possible. The extreme range of the application of the process has made it quite impossible, up to the present time, to standardise every single operation, but these instructions cover the field in such a general way that the operator is prevented from making serious welding blunders. In view of the fact that our practice has been so rapidly developed by this method, it will be necessary, this fall, for us to revise and reprint our standard welding instructions, which at that time will be very complete. Let it suffice to say that the ability of the operator to make good welds requires that he have some knowledge of metals and their properties, especially as regards expansion and contraction, and that his education by the supervisor be thorough and complete. It is now evident to us that the complete instruction and training of the craftsmen in the art of electric welding should be considered as a necessary additional course to the apprenticeship they served when learning their trades, in order to keep pace with the rapid strides being made to-day in mechanical engineering practice. It is the desire of the writer and the intention of this paper more fully to acquaint the railway management with the economic value of the new welding process, both in war and in peace, in order that it may be given the great attention that it so well deserves.

(To be continued.)

CATALOGUES.

Aircraft Paints.—A full selection of paints, varnishes, enamels and wood fillers, for aircraft work is given in a catalogue received from Messrs. Jensen and Nicholson, Limited, Stratford, London, E.15. There are also some rust-preventing lacquers and painting materials for general engineering work.

Second-Hand Machinery.—The catalogue of second-hand machinery issued by Messrs. Thomas W. Ward, Limited, Sheffield, contains a few locomotives and cranes, many steam stationary engines, air compressor and electric generating sets. A fair number of engineers' machine tools including lathes, planers, shapers, slotters, drillers and grinders, are also in the list. Contractors' plant and materials are not so plentiful as usual, but there is still a good deal to select from.

Electric Switches.—Oil break switches operated by electric motors form the subject of a special catalogue issued by the British Thomson-Houston Company, Limited, Rugby. These are for currents of 15,000 volts to 70,000 volts. The motor used is of the high-speed direct-current series wound type acting on springs which are compressed gradually and released suddenly. The catalogue contains full technical information, illustrations and diagrams.

Vertical Drilling Machines.—A very full series of small drilling machines is shown in a catalogue from the Henry and Wright Manufacturing Company, Hartford, Conn., U.S.A., one of those firms which make a specialty of one kind of machine, and do it thoroughly. Machines carrying one to eight spindles, for drills up to ¾ in., with ample speed variations and all fitted with right-angle belts, are made in two classes. Other classes include radial arm and other machines for 1½-in. and 1¼-in. drills. There is also a machine shown for ½-in. drills to run at 12,000 r.p.m. A tapping attachment can be provided and automatic feed fitted to most of the machines. The jockey pulleys have full adjusting devices to make the belt run true at all speeds—a matter not always so carefully attended to. Two speed-tables are given: one for carbon and one for high-speed drills—though one would have done, as the h.s. is always exactly double that of the carbon. These tables are the result of careful research work; but, still, figures like 2,287, 1,307 and 741 as the correct number of r.p.m. for various drills, had better have been rounded off. Cutting speeds are given for eight metals, including 150 ft. for brass, 60 ft. for mild steel, and 20 ft. for cast steel per minute. The specifications and illustrations indicate the best workmanship, ample material and very clean strong lines of design.

Crushing Machinery.—A very fine series of heavy machines is described and handsomely illustrated in a catalogue that comes from Messrs. Hadfield's, Limited, Sheffield. These include a gyrating rock and ore breaker; stone and ore jaw-crusher; portable stone breaker with screens; coal and coke breaker; runner grinding mills for grinding and mixing sand, clay, limestone, slag, &c.; and a series of revolving screens. All these are made in a full range of sizes and manganese steel is largely used in the parts subject to heavy crushing or abrasive action. The gyrating mill stands about 20 ft. high. The crushing cone revolves with an eccentric motion; so that it cracks and then releases the pieces of stone. The larger of these pieces are again caught in the tapered space between the fixed and moving teeth, and crushed again. The finer pieces fall through from any stage and pass away from the mill. This mill is made in six standard sizes. The small size weighs 4 tons and crushes 4 tons to 10 tons of stone per hour, according to size, viz., 1½ in., 2 in. or 2½ in. The largest size weighs 70 tons and crushes 150 tons to 200 tons per hour to 4½-in. size. In the jaw-crusher machine the original Blake design is followed. Practical millwrights will agree with Messrs. Hadfield that the simple original design is quite as efficient as, and generally much stronger than, the "improved" types. In this machine the whole frame is of cast steel, and the jaw faces and side cheeks of manganese steel. A dozen sizes of this machine are made, ranging in working capacity from 5 tons to over 220 tons per hour. The runner mills are of the revolving-pan type with manganese steel tyres for the edge runners and flat ring plate of the same material for the track. Screens are made in a very large number of sizes and a variety of driving fittings. Hardly any class of machinery shows so little change in design and so much gain by improved material, as compared with the machines of, say, over fifty years ago.

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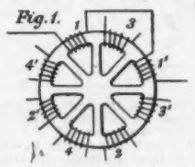
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

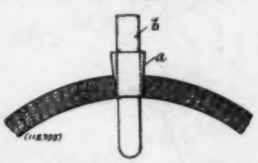
ELECTRICAL APPARATUS.

115,685. British Insulated and Helsby Cables, Limited, Prescot, G. E. Bairsto, South Farnborough, and H. H. Harrison, Knotty, Ash, Liverpool. Loading Coils for Telephone Circuits. (4 *Figs.*) May 15, 1917.—The present invention relates to an improvement in the art of duplex telephony for loading simultaneously the phantom and physical or side circuits. In the use of loading coils there is experienced a defect, giving rise to cross talk between the various circuits of the combination, when any out-of-balance quantities (either electrostatic or electromagnetic) exist. In accordance with the present invention, the defect above alluded to is avoided by the application of the principle of subdivision of windings to coils used for simultaneously loading physical and phantom circuits and, moreover, by the method that is adopted of grouping the windings, both the two physical circuits and the phantom circuit are loaded by the use of one single coil in a more perfect way than hitherto. The



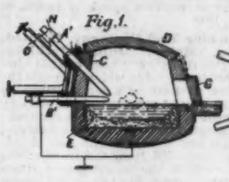
improved coil is constructed as an annular core traversed by a number of diametral limbs magnetically symmetrically. On the annular core are arranged windings in the spaces between the cross limbs. The number of diametral limbs must be either 2, 4, 8, &c., and the number of windings therefore equal to either 4, 8, 16, &c. In Fig. 1 the windings are arranged so that alternate windings belong to the same side circuit, such, for example, as 1 and 1¹ and 2, 2¹, and neighbouring windings belong to different side circuits. In this figure for clearness, only one line of a side circuit is shown. The numbering of the coils, however, clearly shows the proposed arrangement. Coils 1 and 1¹ belong to one line of one side circuit and coils 2 and 2¹ belong to the other line of the same circuit. Similarly coils 3 and 3¹ and 4 and 4¹ belong to the two lines of the second side circuit respectively. The physical or side circuits produce currents indicated by the full arrow heads, while the phantom circuit currents are shown by the dotted arrows. (*Accepted May* 29, 1918.)

115,705. W. B. Hamilton, Sheffield, and J. Holland, Grindleford. Electric Furnaces. (3 *Figs.*) May 25, 1917.—The invention relates to means for preventing the oxidation or wasting of the electrodes employed in electric furnaces. The invention consists in an improved form of heat-conserving means, and is characterised by the employment of an elongated keystone brick or block made in one or several pieces and with a central passage of a bore only slightly larger than the diameter of the



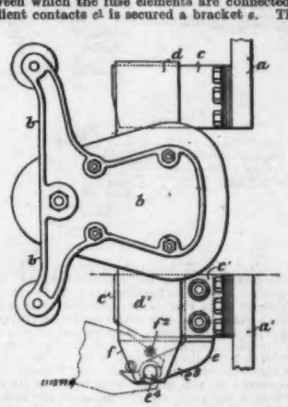
electrode and of a length sufficient to cover the glowing portion to the electrode when withdrawn from the furnace, so that it is not exposed to the outside cold air and consequently oxidation of the electrode is to a large extent prevented and its life very considerably increased. There is built into the roof or walls of an electric furnace at the part where an electrode passes into the furnace an elongated upstanding keystone brick or block *a*, with a central orifice to receive the electrode *b*, which is, of course, free to slide therein. (*Accepted May* 29, 1918.)

115,719. O. Sahlin, London. Electric Furnaces. (2 *Figs.*) June 13, 1917.—This invention relates to electric furnaces for the smelting or refining of metals and consists in an improved arrangement of the electrodes and furnace construction. According to the invention, one or more pairs of electrodes enter the furnace in a side wall, preferably approximately opposite to a charging and discharging door, one electrode of each pair is substantially horizontal and the other, which is placed above it, is inclined downwards, both electrodes being approximately in the same vertical plane, so that the arc is either "free burning," that is, is formed between the two electrodes, or is direct, that is, is formed between the upper electrode and the bath of metal or other conducting material. The electrodes A¹ and B¹ enter the furnace through a wall C, which may be cylindrical, conical or of any other convenient form; the furnace roof shown at D is formed as a circular cupola inclined slightly to the horizontal and adapted to be turned about a nearly vertical axis. E is the lining separating the hearth from the bottom and sides of the furnace. G is a door opposite to the electrodes and through which the charge can be inserted and withdrawn. There may be several pairs of electrodes and at least two pairs for a two-phase and three pairs for a three-phase circuit, and each horizontal



carbon B_1 is connected to a conducting plate at the bottom of the furnace lining. This plate is preferably connected to earth. The electrodes enter the furnace through water-cooled boxes. The electrodes are mounted on carriages N adapted to slide forwards or backwards on frames O by means of screws. (*Accepted May* 29, 1918.)

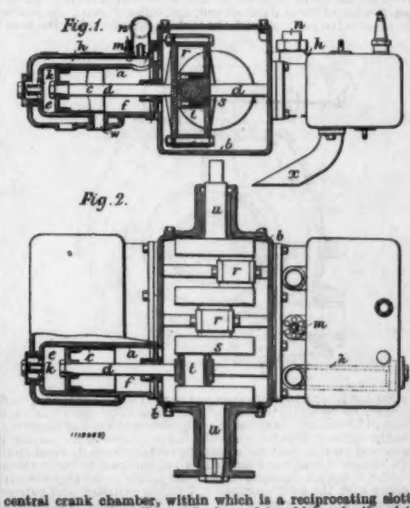
115,779. Switchgear and Cowans, Limited, and G. H. Neep, Salford, Manchester. Magnetic Blow-out Fuses. (5 *Figs.*) December 21, 1917.—According to the invention, the support for the fuse-carrying member consists of a suitably-mounted bracket in which said member is removably pivoted. *c*, *c*¹ are the conductors and *b* is the member which carries the fusible elements (not shown) and the other parts of the fuse. The conductors are provided with resilient contacts *e*, *e*¹, bolted thereto and the member *b* with complementary rigid contacts *d*, *d*¹ between which the fuse elements are connected. To the lower resilient contacts *e*¹ is secured a bracket *s*. This bracket



is formed with lugs which lie between the contacts *e*¹ and are secured thereto by bolts, and also with arms *s*¹ wherein is mounted a shaft *s*⁴. The member *b* carries side plates *f* which are formed with bearing slots adapted to co-act with the shaft *s*⁴ and by means of which the member *b* can be mounted on the shaft and pivot thereon to the operative and inoperative positions, as shown in full lines and indicated in dotted lines respectively, and is at the same time readily removable without disconnecting any part. For supporting the member *b* in the inoperative position, the arms *s*¹ of the bracket *s* are furnished with projections and the side plates *f* with a cross-piece *f*² to rest on said projections. (*Accepted May* 29, 1918.)

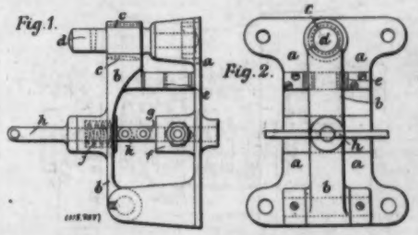
GAS ENGINES, PRODUCERS, HOLDERS, &c.

115,665. C. W. Small, South Kensington, London, and B. Goodhead, Fulham, London. Internal-Combustion Engine. (2 *Figs.*) May 11, 1917.—This invention relates to two-stroke cycle internal-combustion engines of the type in which a pair of cylinders are opposed end to end on either side of a



central crank chamber, within which is a reciprocating slotted yoke which receives the crank-pin, and to which yoke the piston rods of the two opposed cylinders are directly connected. According to the present invention, the above type of engine is characterised by an automatic inlet valve for the combustion chamber, whilst for exhaust the cylinder is fitted with a terminal exhaust port. The engine-cylinders *a* are preferably arranged in threes and opposed to one another on either side of an intermediate crank chamber *b*. Each end of each cylinder is closed and its piston *c* is connected rigidly to the corresponding piston rod *d*. The piston divides the cylinder into two chambers *e* and *f*, of which the outer constitutes a combustion chamber *e*, whilst the other or inner forms a pump chamber *f* for the mixture. Arranged alongside each cylinder is a bye-pass pipe *h*, which at one end communicates with the combustion chamber *e* through an inwardly-opening automatic non-return valve *k*. The other end of the tube communicates with the pump end *f* of each cylinder and is also fitted with an automatic non-return valve *m* which allows the fuel mixture in a feed pipe coming from the carburettor to be drawn into the pump chamber *f*. Each piston rod *d* extends into the crank chamber *b* and is fitted to a slotted yoke *r* adapted to reciprocate, within which is a sliding block *s* mounted on the crankshaft *u*. The series of operations in each cylinder is as follows: Assuming that the piston *c* is about to commence a firing stroke, ignition is effected in any suitable way, driving the piston forward and driving in front of it a previously drawn-in new charge of fuel mixture round towards the combustion chamber *e* of the cylinder, and if desired, also compressing it to some extent. The burnt gases are exhausted by a terminal exhaust port *w* arranged about midway of the cylinder, which is overrun by the trunk piston, and the resulting diminution of pressure allows the new charge to open the inlet valve *k* and pass into the cylinder. The compression stroke now compresses the new charge and at the same time draws a new charge of fuel mixture into the pumping chamber through the valve *m*. Ignition is then effected, and so on. The exhaust port is connected to the usual manifold which is indicated at *z*. (*Accepted May* 29, 1918.)

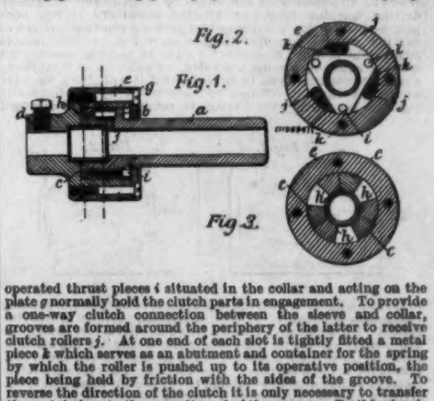
115,707. Peter Hooker, Limited, Walthamstow, and H. Pollard, Reading. Internal-Combustion Engines. (3 *Figs.*) May 26, 1917.—The object of this invention is to provide means for controlling internal-combustion engines, and is especially applicable to engines in which the fuel supply is delivered directly into the crank-case through a jet or number of small holes. According to this invention, the petrol supply and the spark are controlled by a single movement so that the petrol supply is shut off before the sparking switch is closed, so ensuring that all the petrol on the engine side of the control shall be used up and that the sparking switch shall be opened before the petrol supply is opened. *a* is framework to which is pivoted an arm *b* under the control of a worm and wheel *c* on a shaft *d*. The arm operates both the switch and the petrol valve in correct



sequence. The switch is a plain knife switch and is shown at *e*. The petrol valve body is shown at *f*, *g* being the stem of the valve. The stem is so arranged that the switch *e* opens before the end of the stem uncovers the passages in the valve body and permits the petrol to flow from the tank to the engine. This ensures that the petrol is always cut off before the engine is cut out, and *vice versa* the plugs are always sparking before the petrol is turned on. For priming the cylinders preparatory to starting up, a double control is fitted to the stem *g*. This consists of a handle *h* acting against a spring *j* and connected to the stem by a link *k*. Thus, by operating the handle *h* the stem *g* can be withdrawn independently of the switch *e*. The engine is always doped with the switch "in," *i.e.*; with the magneto earthed and no spark at the plugs. (*Accepted May* 29, 1918.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

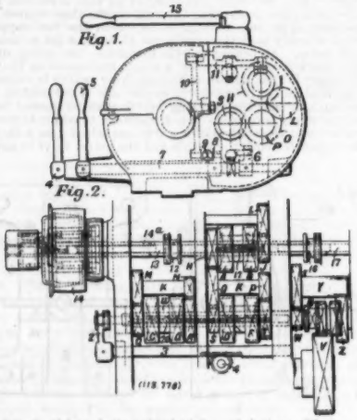
115,694. A. Field and H. W. Ward and Co., Limited, Birmingham. Screwing Appliances. (4 *Figs.*) May 10, 1917.—This invention has for its object to provide an improved appliance for use more particularly with turret lathes. In carrying the invention into effect, a cylindrical stem *a* has a collar *b* formed integrally with it near one end. One face of this collar is provided with clutch projections *c* and the end of the stem adjacent to such projections has mounted on it a tap or die holder *d*. A sleeve *e* is mounted on the collar and the holder *d* is connected with a plate *g* on the stem behind the collar. A certain amount of free axial movement of the holder, sleeve and plate is permitted so that clutch projections *h* on the holder *d* can engage and disengage the projections *c* on the collar. Spring-



operated thrust pieces *i* situated in the collar and acting on the plate *g* normally hold the clutch parts in engagement. To provide a one-way clutch connection between the sleeve and collar, grooves are formed around the periphery of the latter to receive clutch rollers *j*. At one end of each slot is tightly fitted a metal piece *k* which serves as an abutment and container for the spring by which the roller is pushed up to its operative position, the piece being held by friction with the sides of the groove. To reverse the direction of the clutch it is only necessary to transfer the metal piece to the opposite end of the groove. By this simple device the one-way clutch is readily adapted for operating in either direction. By providing a plurality of holders, the main part of the one appliance can be used for a large range of dies

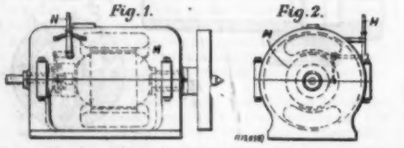
and taps. In operation, the dies or taps are held rigidly whilst acting on the rotating work-piece until the turret engages a stop, when the interaction of the work and the dies or tap draws forward the holder and releases it from clutch connection with the stem. The screwing action then ceases. On reversing the rotation of the work-piece, the one-way clutch comes in action and holds the dies or tap while the latter are being withdrawn. (*Accepted May* 29, 1918.)

115,778. J. Macnab, Marple, and G. H. Smith, Marple. Headstocks. (3 *Figs.*) December 20, 1917.—The present invention comprises a multi-gear headstock in which all the high-speed gears are reversible and are brought into action by friction clutches, the final or slow-speed drive to the lathe or like spindle gear being through a sliding gear type of clutch interconnected with a clutch for the main driving pulley, so that the latter clutch is always put out of service before the sliding gear clutch is brought into action. The belt pulley 14 by which the headstock is driven is adapted to be clutched to its shaft 14*a* by a friction clutch operated by the sliding rod 13 disposed within the spindle 14*a* and actuated from the sleeve 12 by a pin passing through the rod 13 and moving in a slot in the spindle 14*a*. The latter carries two clutches A, B, one driving the gear wheel H and the other the gear wheel J. The two clutches A, B are actuated by a rod 17 connected to a sliding collar 16, similar to the collar 12. The gear wheel H drives the spindle K direct by the gear wheel O, whilst the gear wheel J can drive the said spindle through the intermediate gear wheel L and wheel P. The shaft K also has keyed thereon two pinions M, N. Each of the pinions M, N, O, P is adapted to drive the spindle U through gear wheels and clutches Q, C; R, D; S, E, and T, F respectively, the clutches C, D, E, F being controlled by a rod 20 actuated from a rod 3 by a connecting piece 2. Only one of the clutches C, D, E, F is in operation at any one time. The shaft U has a wheel W keyed thereon which can, by means of the sliding



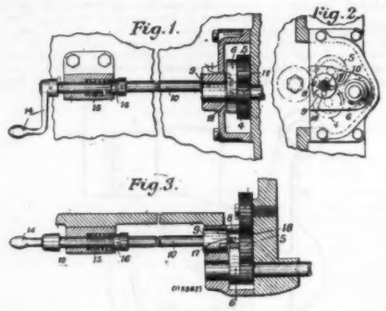
gear wheel G, be caused to drive the lathe or like spindle gear V. The said wheel W can also drive the wheel V through the back gear X, Y, Z, the latter wheel Z in that case being engaged by one sliding gear wheel G. The control of the clutches C, D, E, F is effected by a handle on the spindle 4 carrying a pinion engaging the racked portion of the rod 3. The clutches A and B are controlled by the hand lever 15 which operates the sliding collar 16. The control mechanism for the gear G is interconnected with the operating mechanism of the clutch of the pulley 14 as follows:—The handle 5 is mounted upon the spindle 7 carrying two crank arms 6 and 8, the one, 6, having an elongated slot therein so that a predetermined amount of idle movement may occur between the period of actuating of the handle 5 and the period of actuation of the member by which the sliding gear G is moved for engaging either the wheel W or the wheel Z. The arm 8 actuates a rod 9, which engages one end of a lever 10, the other end of which actuates a lever 11 engaging the sliding collar 12. With this arrangement, and with the parts in the positions shown in Fig. 2, when it is desired to cause the sliding gear wheel G to engage the wheel W, the handle 5 is moved. During the first part of its movement, the arm 8 puts the friction clutch of the pulley 14 out of action, whilst the arm 6 has an idle movement. Then the said arm slides the wheel G towards the gear W. Finally the wheel G is caused to engage the gear W at the same time that the clutch of the pulley 14 is brought into action. (*Accepted May* 29, 1918.)

115,655. H. Scholey, Westminster, London. Driving Machine Tools. (4 *Figs.*) April 4, 1917.—This invention refers to a method of or and means for individually electrically driving machine tools. In winding machinery it has been proposed to employ a series system giving a constant current of varying voltage for operating series-wound electric motors adapted to produce a constant torque at varying speed, such system comprising a motor generating set and such set comprising a generator series wound in suchwise that it will give a constant current at varying voltages and controlled by an automatic regulator for moving the brushes in combination and arranged



to act in conjunction with the series motor to operate the winding mechanism adapted to produce a constant torque at varying speeds. The applicant has found that this system can be adapted and usefully applied for individually electrically driving machine tools and the invention consists in the application and use of said system for the said purpose. Thus the system to operate electric motors for the purposes according to the present invention is one giving a constant current with varying voltages, thus reversing the operation of the ordinary commercial electrical system for driving machine tools. The series motor operated on the system and for the purposes according to the present invention, will give a constant torque at varying speeds for driving said machine tools. Assuming a specially designed series motor connected to such a system according to the present invention the desired speed regulation can be obtained by the simple method of shifting the brushes, and this arrangement would dispense with any resistance. The drawings illustrate a series motor M provided with a handle H by which the brushes can be readily moved over the commutator in order to produce speed variation, as aforesaid. (*Accepted May* 29, 1918.)

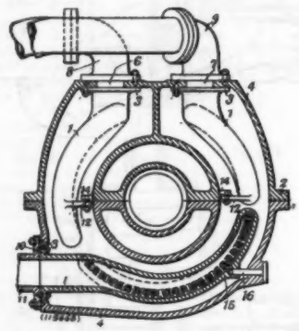
115,982. The Robson Machine Tool Company, Limited, Bradford, and H. E. Kitchen, Shipley. Milling Machines. (3 *Figs.*) August, 9, 1917.—This invention relates to that kind of milling machine wherein the sliding table which supports the work is traversed through the medium of a screw driven by train of gear wheels fitted with a hand-operated mechanism by which the direction of movement of the said table is reversed; and the object of this present invention is to provide the reversing mechanism with a self-locking device of efficient and simple construction capable of being controlled from the front of the machine. According to this invention, the reversing gear wheels 4, 5, are carried on a pivoted plate 6 adapted to be rocked through the medium of an eccentric pin 8 carried by a collar 9 fixed on the rear end of a hand-operated shaft 10 made capable of a longitudinal sliding movement in front and rear end bearings, while around the said slidable shaft and within its front bearing is mounted a spiral spring 15 which is held in compression between the inner face of the said bearing, and a fixed collar 16 provided on the shaft. This slidable shaft is adapted to be drawn forwardly against the action of the spring 15 through the medium of a hand lever 14 fixed on its front end, while the rear end of the shaft beyond its rear bearing is provided with a rearwardly-



projecting central pin 17 adapted to engage locking holes 18 formed in the pivoted rocking plate 6, and hold it in position to effect the drive. When the rocking plate 17 is required to be moved, the shaft 10 is first drawn forward against the action of its spring 15 sufficient to only withdraw its central pin 17 from engagement with the plate, and then turned so as to cause its central pin 8 to rock the plate into the desired position and bring its corresponding hole into alignment with the central pin of the shaft, after which the shaft is released, when it becomes instantly slidden rearwardly by the spring so as to cause its end pin to engage the hole in the plate and so automatically lock the latter in the moved position. It will thus be seen that in order to effect the reverse, the slidable shaft is merely drawn forward by its hand lever against the action of the spring so as to withdraw the end pin from engagement with the rocking plate prior to rotating the said shaft through the same hand lever to rock the plate which carries the reversing gear wheels; the arrangement constituting a self-rocking device of simple construction capable of being controlled from the front of the machine. (*Accepted June* 5, 1918.)

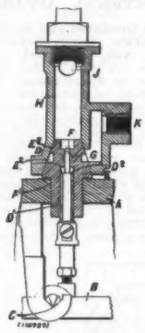
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

115,666. K. Baumann, Barnfield, Urmston. Steam Turbines. (1 *Fig.*) May 11, 1917.—In the specification of Patent No. 105,370 there is described a removable nozzle-box for steam turbines of the axial flow type which is closed at one end and has its other end, through which the steam is admitted, secured to the side of the turbine cylinder, and is so constructed that it may be inserted endwise in a substantially tangential direction relatively to the moving blades through a comparatively small opening in the side of the turbine cylinder. The present invention is a modification of the invention described in the specification of the said patent and, according thereto, the nozzle-box is placed in position with the turbine cylinder when the latter



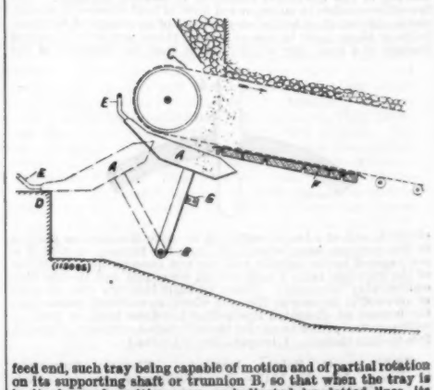
is open and is secured at its open end to the interior of the turbine cylinder, or to an extension of the steam pipe or other part attached to the turbine cylinder. The nozzle boxes 1 are inserted into the turbine cylinder when the latter is opened at the usual horizontal joint 2, said boxes being provided at their open ends with flanges 3 which are secured to the interior of the turbine cylinder 4, so that the open ends of the nozzle boxes respectively register with the port openings 6, 7 in the cylinder and corresponding steam supply pipes 8, 9. The lower nozzle-box is secured to a flange 10 on the steam pipe 11, said flange being bolted to the port opening in the cylinder. For maintaining the nozzle boxes in their proper relative position within the turbine cylinder with reference to the turbine blades, the means shown in connection with the two upper nozzle boxes comprise a lug 12 cast on the exterior of the nozzle-box and furnished with a pin adapted to slide in another lug 14 on the turbine cylinder. The lower nozzle has a projection 15 cast on it which is provided with an orifice adapted to receive a pin 16 secured in the turbine cylinder 4 (*Accepted May* 29, 1918.)

115,725. A. H. Anthony, Colchester. Boiler-feed Apparatus. (1 *Fig.*) June 20, 1917.—This invention relates to float-operated valves in boiler-feed apparatus of the type described in British Letters Patent No. 16,097/1902 and No. 103,513. Feed apparatus of this type includes a float-operated valve employed to control the escape of fluid that has leaked under high pressure past a piston which is a balancing or controlling piston for the boiler-feed check valve. The present invention resides in the selection for the float-operated valve in apparatus of the type defined, of a piston valve of small diameter. The top of the float-box is indicated at A, portion of the float arm at B, and the pivot of the arm at C. The valve operated by the float is seen at D, D^1 and is in the form of two co-axial cylinders, one, D, of which is of small diameter, say, about ¼ in., and the other, D^1, of which is larger, say, about ½ in. Where the parts D, D^1 meet, a square shoulder D^2 is left. The portion D con-



stitutes the valve and the portion D^1 its guide. The free end of the valve is coned or rounded. A combined guide-way and seating E is formed from a single block of metal by boring two co-axial cylindrical holes F, F^1 therein, the smaller, F, extending to one face of the block to constitute the seating for the piston valve D, and the other, F^1, extending to the other face of the block to constitute a way for the guide D^1. The block E is formed with a cylindrical stem E^1 and a conical head E^2. The latter is ground to make a steam-tight fit with a correspondingly-coned hole in the bottom of the valve chest H, and the stem E^1 enters a hole in the cover A of the float-box, with which joint is made under the shoulder of the head E^2 in any convenient manner. The valve chest H is bolted down on to the cover A by means not shown in the drawing, and so holds both joints steamtight. The valve chest H has an inlet J for the leak water from the boiler feed and an outlet K communicating with an annular recess E^3 in the block with which the duct G communicates. (*Accepted May* 29, 1918.)

115,086. F. C. Stellens, Wandsworth, London. Chain Grate Stokers. (1 *Fig.*) April 25, 1917.—With many forms of stokers and certain forms of fuel, there is a considerable loss of the latter, owing to what are known as riddlings or small coal that pass through the links, and, normally, are deposited in the front of the ash pit where they are from time to time removed, and, necessarily, before the removal of the ordinary ash or clinker from the back of the ash pit if the fuel is not to be lost. The object of the present invention is to collect the riddlings or small coal that pass through the links and, normally, are deposited in the front of the ash pit and deliver them at a point external to the ash pit, say, on the firing floor, from whence they can be easily removed as occasion demands, and refired. According to this invention, and as shown in the drawing, it is proposed to employ a tipping tray A suitably pivoted, say, at B, and, if desired, counterweighted, which, in its inner position, would extend for some little distance beneath the chain grate C at the



feed end, such tray being capable of motion and of partial rotation on its supporting shaft or trunnion B, so that when the tray is in its forward position, say, as indicated by dotted lines, its lower edge and its then inclined bottom will rest on the firing floor D upon which the riddlings would be partially discharged. The illustration shows the invention in its simplest form only, but it will be obvious that in installations where it is desired that the tray A should extend further under the grate any of the known methods of translation and carrying the tray can be employed. For convenience, a suitable handle E for drawing forward the tray may be affixed thereto, and in conjunction with said tray a fixed plate F at a slight distance below the returning travelling grate C may be employed, the action being such that the movement of the grate causes riddlings which have fallen on to the plate to be carried forward and discharged into the tray A, the inward movement of which may be limited by a stop G. (*Sealed.*)